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THE MARINE ALGAE OF THE PACIFIC COAST OF NORTH AMERICA

PART II
CHLOROPHYCEAE

BY
WILLIAM ALBERT SETCHELL
AND
NATHANIEL LYON GARDNER

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THE MARINE ALGAE OF THE PACIFIC COAST

The second part of the Marine Algae of the Pacific Coast of North America, comprising an account of the Chlorophyceae or Green Algae, succeeding an account of the Myxophyceae, is presented without introduction or explanation, pending the publication of the other two parts which are in advanced preparation. It is intended to issue with the completed volumes a statement as to the principles followed, methods used, territory covered, sources of information, material, etc., as well as to make acknowledgment to the various authorities, students and collaborators who have been of the greatest assistance in carrying out the long and laborious task.

W. A. Setchell and N. L. Gardner.

latter being either septate (i.e., provided with partitions, as in the Siphonocladiales) or destitute of septa (as in the Siphonales), and ranging in size from microscopic forms to individuals of more than a meter in at least two dimensions; cell walls varying in structure and composition, mostly of cellulose but sometimes largely of pectose, occasionally more or less externally mucilaginous, generally simple, moderately thick and structureless, but at times thick and variously stratified, occasionally incrusted with lime; nuclei well developed; chromatophores usually distinctly differentiated, of varying shape and number, often containing starch centers, or pyrenoids, and colored by chlorophyll and xanthophyll, the former usually in excess; reproduction vegetative, by non-sexual spores, and by zygotes; vegetative reproduction by cell division, fragmentation, and by gemmae

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THE MARINE ALGAE OF THE PACIFIC COAST OF NORTH AMERICA

PART II

CHLOROPHYCEAE

BY

WILLIAM ALBERT SETCHELL
AND
NATHANIEL LYON GARDNER

Subclass 2. CHLOROPHYCEAE Kuetzing

Thallophytes containing only the pigments, chlorophyll and xanthophyll; thallus varying from strictly single cells (uninucleate), or more or less simple or complex colonies (as in the Protococcales), to multicellular individuals which are either made up of cells (i.e., uninucleate divisions, as in the Ulvales, Schizogoniales, and the Ulotricales) or are coenocytes (i.e., of multinucleate divisions), the latter being either septate (i.e., provided with partitions, as in the Siphonocladiales) or destitute of septa (as in the Siphonales), and ranging in size from microscopic forms to individuals of more than a meter in at least two dimensions; cell walls varying in structure and composition, mostly of cellulose but sometimes largely of pectose, occasionally more or less externally mucilaginous, generally simple, moderately thick and structureless, but at times thick and variously stratified, occasionally incrusted with lime; nuclei well developed; chromatophores usually distinctly differentiated, of varying shape and number, often containing starch centers, or pyrenoids, and colored by chlorophyll and xanthophyll, the former usually in excess; reproduction vegetative, by non-sexual spores, and by zygotes; vegetative reproduction by cell division, fragmentation, and by gemmae

(or cysts); non-sexual spores either motile (zoospores, zoogonidia, or planospores) or non-motile (aplanospores, formed inside the wall of the original cell, and akinetes where the outer wall of the original cell is included in the spore formation); zygotes formed either from isogametes (either isoplanogametes, i.e., both equal and motile, or isoaplanogametes, i.e., both equal and non-motile) or from anisogametes (or heterogametes, i.e., unlike gametes); germination of the zygote various.

Chlorophyceae Kuetzing, Phyc. Germ., 1845, p. 118; Wille, *in* Engler and Prantl, Natürl Pflanzenfam., 1 Th., 2 Abt., 1897, p. 24; Oltmanns, Morph. und Biol. der Alg., vol. 1, 1904, p. 133; West, Algae, vol. 1, 1916, p. 126. *Chlorospermeae* Harvey, *in* Mackay, Fl. Hibern., part III, 1836, p. 163, Genera So. African Plants, 1838, p. 403.

Harvey seems to have been the first to propose the classification into green algae, brown or olive-green algae and red algae, as now usually adopted, and coined the names Chlorospermeae, Melanospermeae and Rhodospermeae. In his Chlorospermeae, he included also what are now separated under Myxophyceae, very few of which, however, were known to him. Kuetzing was the first to use the ending phyceae, but his Chlorophyceae included both the Chlorospermeae and Melanospermeae of Harvey and is consequently very different in its content from that of more recent writers.

There is some difference of opinion, even at present, as to the exact content of the Chlorophyceae. It has seemed best to follow West (1916, p. 126) in including also the Conjugatae as well as the groups with zoospores, although the decision assumes no practical importance in the present account, since none of the Conjugatae is properly marine.

The great majority of the marine Chlorophyceae are inhabitants of the littoral belt, a few descending to the upper portion of the sublittoral belt, while those occurring in deeper waters are, so far as the extra tropical portions of the Pacific Coast of North America are concerned, very few indeed.

The great majority of the Chlorophyceae are either subaerial or inhabitants of strictly fresh waters, so that a number of the important groups are not found in the salt waters. Unfortunately for this account, also, the strictly tropical waters of the Pacific Coast of North America are, as yet, unexplored, and little is known as to the occurrence, or non-occurrence, of the more complex forms of the Codiaceae,

Valoniaceae and the Caulerpaceae. Undoubtedly many species of these families will be added later when the algal flora of the Pacific coasts of Mexico and Central America is collected and made known.

CHLOROPHYCEAE

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Series 1. ISOKONTAE Blackman and Tansley

Unicellular, multicellular and coenocytic Chlorophyceae, reproducing by means of zoospores or planogametes provided with two or four equal cilia or, when multinucleate, with the cilia arranged in pairs (Vaucheriaceae) or exceptionally in a circle (Derbesiaceae).

Isokontae Blackman and Tansley, Revis. Class. Green Algae, 1902, p. 20; West, Algae, vol. 1, 1916, p. 156.

It has seemed best to adopt the classification as outlined by West (1916, p. 153), dividing the Chlorophyceae into four series according to the character and arrangement of the cilia of the zoospores and the planogametes. West adopts four series, viz., Isokontae, Akontae, Stephanokontae and Heterokontae. Of these, our marine flora has to deal only with the first, the Isokontae, where the cilia are equal and arranged in twos or fours. The other groups are not represented. Only two seeming exceptions need explanation. In the Vaucheriaceae the zoospore is large and covered with cilia. They are, however, arranged over the surface in pairs. The other, and only real, exception is the Derbesiaceae, where the cilia are arranged in a circle as in the Stephanokontae. It has seemed best to leave the Derbesiaceae with the Isokontae in this account, since this is the usual arrangement, but it is done with some reservation of opinion.

Key to the Orders

1. Thallus of true cells (uninucleate segments) 2
1. Thallus coenocytic (of multinucleate segments) 6
2. Cells solitary or in non-filamentous colonies ..... 1. **Protococcales** (p. 143)
2. Cells in filaments or membranes 3
3. Thallus filamentous 4
3. Thallus membranaceous 5
4. Filaments simple or, more often, branched; chromatophore parietal ..... 6. **Ulotrichales** (p. 281)
4. Filaments simple; chromatophore axile ..... 5. **Schizogoniales** (p. 275)
5. Chromatophores parietal ..... 4. **Ulvales** (p. 233)
5. Chromatophores axile ..... 5. **Schizogoniales** (p. 275)
6. Thallus septate ..... 3. **Siphonocladiales** (p. 179)
6. Thallus non-septate ..... 2. **Siphonales** (p. 153)

Order 1. PROTOCOCCALES (Meneghini) Oltmanns

Unicellular isokontae, motile or nonmotile, often occurring singly or in larger or smaller, definite or indefinite colonies or coenobia, or even simple coenocytes, often provided with mucilaginous teguments of more or less ample dimensions and of various shapes, never properly multicellular; number and shape of chromatophores (chloroplasts) various; pyrenoids often present; reproductive methods various as outlined for the series Isokontae.

Protococcales Oltmanns, Morph. und Biol. der Algen, vol. 1, 1904, p. 169; West, Algae, vol. 1, 1916, p. 160. *Protococcoideae* Meneghini, Cenni sulla organ. e. fisiol. delle Alghe, 1838, p. 4 (of reprint); Blackman and Tansley, Revis, Class. Green Algae, 1902, p. 21; Wille, *in* Engler and Prantl, Natürl. Pflanzenfam., Nachtr. zum 1 Th., 2 Abt., 1909, p. 3.

The Protococcales, or Protococcoideae as they have long been designated, form a rather large and seemingly heterogeneous order. They are mostly inhabitants of the fresh waters and, although unicellular in the broad sense, are varied in their form, aggregation and methods of reproduction. Our marine species are few so far as known, but undoubtedly a considerable number yet remain to be detected. This is particularly true of the endophytic species of our coast whose presence and development are very little understood at present.

Key to the Families

1. Thallus of larger or smaller colonies (or aggregations of cells).....1. **Palmellaceae** (p. 143)
1. Thallus strictly unicellular.....2. **Chlorochytriaceae** (p. 146)

family 1. PALMELLACEAE (Decaisne) Naegeli

Cells united into larger or smaller colonies by mucilaginous modification of the outer walls, usually provided with a single parietal chromatophore (chloroplast) containing a single pyrenoid; reproduction by biciliated zoospores or by isoplanogametes; fragmentation of colonies often takes place.

Palmellaceae Naegeli, Die neuern Algensyst., 1847, p. 123; West, Algae, vol. 1, 1916, p. 183. *Palmelleae* Decaisne, Essai sur une classe des Algues, etc., 1842, p. 327.

The names Palmellaceae and Palmelleae are used with different intent and to different extent by various writers and are interchangeable wholly or in part with other family designations. It has seemed best to follow West as to the usage in this account. The fundamental idea is that of the colony the cells of which are held together by means of the mucilaginous material produced by the transformation of the outer walls. Some of the colonies are microscopic while others are of considerable size reaching a length (e.g., in some species of *Tetraspora*) of 15 to 20 centimeters. The mucilaginous modification may be general or it may be localized on each cell wall, and the shape, as well as the size, of the colony may thereby be influenced. The cells possess a single parietal chromatophore with a single pyrenoid. Colonies may split up and multiply the plant. Reproduction by zoospores and planogametes is the rule. In zoospore formation several (4 or 8) may arise in a zoosporangium or an ordinary cell may be transformed directly into a zoospore. This latter method, as well as the general cell structure and colony formation, points directly toward relationship with the Volvocaceae.

1. **Collinsiella** S. and G.

Frond gelatinous, solid or later hollow, composed of pyriform cells, on dichotomous, gelatinous stalks tapering downward from the cells; all enclosed in the general gelatine; chromatophore band-shaped, with one large pyrenoid; the terminal cells become the zoosporangia(?)

Setchell and Gardner, Alg. N.W. Amer., 1903, p. 204.

There is a reason for difference of opinion as to whether *Collinsiella* is to be retained as an independent genus or merged with the genus *Ecballocystis* Bohlin. It has seemed best to place the discussion under the single species known from our coast.

Collinsiella tuberculata S. and G.

Plate 10, figs. 4–10

Colonies rugose-tuberculate, 2–4 mm. diam., dark green, gelatinous, firm, attached by a broad base; cells pyriform, 5–12μ diam., 12–20μ long; branches repeatedly dichotomous, proceeding in two planes perpendicular to each other and to the surface of the colony, some of the cells of the dichotomies pushing forward, forming the cortex, leaving behind the translucent, stalklike, gelatinous cell walls, while growth

of other cells of the dichotomies is suppressed and they remain within the colony; the cell stalks show strong cellulose reaction to Chloriodide of Zinc; the cortical cells are changed into zoosporangia(?) containing 8–16 or occasionally more zoospores.

Growing on rocks and pebbles in tide pools in the middle and upper littoral belts. West coast of Whidbey Island, Washington, Port Renfrew, Vancouver Island, Farallones Islands and Point Carmel, California.

Setchell and Gardner, Alg. N.W. Amer., 1903, p. 204, pl. 17, f. 1–7; Collins, Green Alg. N. A., 1909, p. 141; West, Algae, vol. 1, 1916, p. 188; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 909. *Ecballocystis Willeana* Yendo, Three species of marine *Ecballocystis*, 1903, p. 199. *Ecballocystis tuberculata* (S. and G.) Wille, Nachträge, 1909, p. 28 (in part).

Wille (1909, p. 27) places *Collinsiella* as a synonym under *Ecballocystis* Bohlin, but Collins (1909, p. 141) and West (1916, p. 188) keep it distinct. It seems to differ from *Ecballocystis* in forming an extended and definite gelatinous thallus, in the more vertical and regular division of the cells, and in the longer gelatinous stalks to the cells. Because of the first of these differences, West (*loc. cit.*) places it in the subfamily Palmophylleae of the Palmellaceae and next to *Palmophyllum*. This disposition of the genus seems to be the most satisfactory and is adopted here. Collins (1909, p. 141) assigns the *Ecballocystis Willeana* Yendo, from Port Renfrew, British Columbia, to *Collinsiella tuberculata* S. and G. as a synonym, and draws his description from both those of Yendo and of Setchell and Gardner. Yendo, however, in his remarks (1903, p. 204) states that it seems to him highly probable that *Collinsiella tuberculata* may be a young and sterile form of a plant closely related to his *Ecballocystis Willeana*, if not the same species. We have not had the opportunity of examining a plant of *Ecballocystis Willeana*, but judging from Yendo's description and plates, there are some differences. In the Whidbey Island plant there is a sort of basement membrane from which bullate swellings rise as indicated in the habit figure of Setchell and Gardner (1903, pl. 17, f. 1). Yendo figures isolated, much folded thalli (1903, pl. 8, f. 1) attached by rhizoidal outgrowths on the underside (*loc. cit.*, pl. 8, f. 2, 6, 12). No such outgrowths have been detected in the plant from Whidbey Island or in any others of our collections. These are, perhaps, minor and unessential differences, but they indicate that there is a reason to feel uncertain as to the absolute

identity of the two plants. The specimens from the central Californian coast, on the other hand, resemble more closely the Yendo plant in habit but show no attaching fibrils.

Family 2. Chlorochytriaceae nom. nov.

Thallus unicellular, not united into colonies, or single unseptate coenocytes, reproducing solely by zoospores and by isoplanogametes.

Planosporaceae West, Algae, vol. 1, 1916, p. 209. *Endosphaeraceae* Klebs, Organ. einig. Flagellaten-Gruppe, 1883, p. 344; Hansgirg, Prodr. d. Algenfl. v. Böhmen, II, 1888, p. 124; Blackman and Tansley, Rev. Class. Green Algae, 1902, p. 95.

This is a small but fairly natural family including a number of genera which are, however, mostly inhabitants of the fresh waters. West (1916, p. 212) has reduced a number of genera under *Chlorochytrium,* as indicated elsewhere, among them being *Endosphaera.* West has, consequently, set aside the family name Endosphaeraceae, as adopted by Blackman and Tansley, and substituted the designation "Planosporaceae." Since this does not embody one of the genera of the family as reorganized it seems best to consider it inapplicable under the present rules of nomenclature and to adopt "Chlorochytriaceae" as a fitting family name.

As stated by West, "this family is established to include all those non-coenobic members of the Protococcales which are reproduced solely by zoogonidia or isoplanogametes." The great majority of the members of this family are either epiphytic or endophytic.

Key to the Genera

1. Cells spherical to more or less ovoid.....2. **Chlorochytrium** (p. 146)
1. Cells cylindrico-oblong with a more or less elongated stipe.....3. **Codiolum** (p. 151)

2. **Chlorochytrium** Cohn

Thallus unicellular, rounded, with chromatophore covering more or less of the outer wall and continuous or with radial prolongations, containing one to several pyrenoids; asexual reproduction by akinetes or by 2- or 4-ciliated zoospores escaping singly or enclosed in a gelatinous mass; sexual reproduction by 2-ciliated isogametes escaping in a gelatinous utricle mass and conjugating before separation, or escaping singly and conjugating in the water; zygote, 4-ciliated, at first motile, later coming to rest and penetrating the host plant.

Cohn, Ueber parasitische Algen, 1872, p. 102, diagnosis.

West reduces *Endosphaera* Klebs, *Scotinosphaera* Klebs, *Chlorocystis* Reinhardt and *Stomatochytrium* Cunningham to one genus and unites that with *Chlorochytrium* Cohn. "They all agree in being holophytic, unicellular, spherical or nearly so, wholly or partly endophytic plants with a single chromatophore, covering the wall more or less completely and containing one or more pyrenoids. Reproduction is by plano-gametes or by zoospores or by both" (cf. Gardner, 1917, p. 383). It seems best to follow West in his conception of the genus and our species are, consequently, assigned to *Chlorochytrium* in this extended sense. The three species thus far credited to our territory are immersed in the tissues of various membranous or expanded red algae.

Key to the Species

1. Cells with apiculate tips.....1. **C. inclusum** (p. 147)
1. Cells without apiculate tips..... 2
2. Cells spherical, chromatophores with one pyrenoid.....
.....3. **C. Porphyrae** (p. 150)
2. Cells clavate or ovoid, chromatophores with two or more pyrenoids.....
.....2. **C. Schmitzii** (p. 149)

1. **Chlorochytrium inclusum** Kjellm.

Plate 13, fig. 1

Cells in the vegetative condition, spherical or subspherical, entirely included within the host plant, at the time of the formation of the zoospores, slightly elongated, depressed conical, ampullaeform, ovoid or ellipsoid, at length exposed through the penetration of the cortical layer of the host by the apiculate tip, emitting the zoospores through an ostiole.

Endophytic in the fronds of various membranaceous algae, e.g., *Iridaea, Weeksia, Constantinea,* etc. Probably common along the coast from Sitka, Alaska, to Puget Sound, Washington.

Kjellman, Alg. Arctic Sea, 1883, p. 320, pl. 31, f. 8–17; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 206?; Collins, Green Alg. N. A., 1909, p. 147 (in part); Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 514?; Tilden, Amer. Alg. (Exsicc.), no. 389?.

The description, given above, is a fairly literal translation of the Latin diagnosis of Kjellman, who adds certain details in his remarks. The original host is *Dilsea integra* (Kjellm.) Rosenv. (*Sarcophyllis arctica* Kjellm.). The cells of the *Chlorochytrium* are placed, in most

cases, near the surface of the host plant but sometimes occur in the middle layer. In vegetative condition the cells are from 80μ to 100μ in diameter, the cell wall is thin and of equal thickness throughout, while the chromatophore is thin and spread over the whole wall. The wall becomes thicker and apiculate at the outer end as the cell passes into the reproductive stages, the apiculate wall piercing the outer cortical tissues of the host. Kjellman states that the contents divide into a large number of closely packed zoospores which escape through an opening formed by the dissolution of the wall at the tip of the cell. These latter statements are evidently inferences because he distinctly says that he had only dried specimens for examination.

In an authentic specimen of the host plant distributed by Kjellman, young cells of the *Chlorochytrium* were found nearly spherical in shape, with uniformly thin walls, and with a chromatophore thin and dotted with numerous large pyrenoids. These cells are about 80μ in diameter.

Upon examining various specimens referred to this species, the conclusion has been forced upon us that there is some variety of species and possibly even of genera among the Pacific Coast plants referred to *Chlorochytrium inclusum* and it seems practically demonstrated that no one of those accessible to us is clearly the plant of Kjellman.

Very little can be accomplished from the study of dried specimens, but living specimens should be studied to obtain more exact information as to structure and development. Our present knowledge, even of the type, is so slight as to admit of little certainty, and Kjellman's statements as to the formation and emission of "zoospores" need to be carefully verified.

On reëxamining the various specimens referred to this species from our coast, we are able to make only a few general statements.

Freeman (1899, p. 186) describes a plant which he provisionally refers to *Chlorochytrium inclusum*, but he found only vegetative stages. It was endophytic in the blades of *Constantinea subulifera* Setchell. In the Algae of Northwestern America (1903, p. 206), we referred several specimens to the same species. Of these we may distinguish, at least, two very different kinds of endophytes. The first kind includes what are probably species of *Chlorochytrium*, possessing a single chromatophore with numerous starch centers, while the second is made up of plants seemingly possessing neither chromatophores nor chlorophyll and certainly devoid of starch. No. 290, N. L. Gardner,

on *Iridaea* from the west coast of Whidbey Island, Washington, shows small plants ($40\mu \times 80\mu$), broadly pyriform and with thick walls. It is to be referred provisionally to *Chlorochytrium*, but does not agree with Kjellman's description. No. 514, of Collins, Holden and Setchell's Phycotheca Boreali-Americana, shows large, thin walled cells, depressed vertically and measuring about 160μ by 240μ, seemingly a *Chlorochytrium*, but not in accord with the descriptions of either Kjellman or Freeman. The other references given by us, with the exception of Tilden's no. 389, which is Freeman's plant, are to be rejected. They are found to be based upon plants of the second type, which is probably *Chytridiaceous*, possibly being near to *Rhodochytrium*. They are probably the so-called gland cells mentioned by Schmitz as occurring in *Turnerella Mertensiana* (P. and R.) Schmitz (1896, p. 372) and figured as occurring in *Iridaea affinis* P. and R. (Postels and Ruprecht, 1840, pl. 40, f. 93). We have selected for illustration (pl. 13, f. 1) plants occurring endophytic in *Weeksia Fryeana* Setchell collected by Gardner near Sitka, Alaska. These seem to correspond more nearly than any of our other specimens with the description and figures of Kjellman.

2. **Chlorochytrium Schmitzii** Rosenv.

Cells clavate or ovoid, with rounded apex, without cone-shaped thickening of the cell wall, and with pointed base; up to 370μ long by 90μ diam.; chromatophore single, occupying the greater part of the cell wall, and with two pyrenoids.

Growing in various incrusting marine algae, e.g., *Petrocelis*. Alaska.

Rosenvinge, Groenl. Havalg., 1893, p. 964, f. 56; Collins, Green Alg. N. A., 1909, p. 147; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 206 (in part).

In our Algae of Northwestern America (1903, p. 206), we referred two specimens to this species, one from Harvester Island in Uyak Bay, on the Island of Kadiak, Alaska, and another from the west coast of Whidbey Island, Washington. On reëxamination of these specimens it seems best to retain the former under this name, in spite of certain differences between it and the figures and descriptions of the Greenland plant as given by Rosenvinge. Certain of the cells in our specimens are rounded above and pointed below, seemingly in vegetative condition. Other cells have papillate swellings at one or both

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ends and are probably reproducing since the contents seem more or less broken up. There is no trace of a stalk (or tail) as in *Codiolum*, nor is the shape that of the cell (or clava) of that genus. Therefore it seems best to retain our Alaskan plant in *Chlorochytrium* and to refer it to *C. Schmitzii* pending further investigation of living material.

The Whidbey Island plant referred here has also been carefully reëxamined. In the shape of the "clava" and in the occasional possession of a stalk (or tail), it shows itself to be a *Codiolum* and is discussed below under that genus.

The Alaskan plant referred to this species varies in height from 123μ up to 220μ, and in width from 54μ to 66μ, thus coming within the measurements as given by Rosenvinge for *Chlorochytrium Schmitzii*.

3. **Chlorochytrium Porphyrae** S. and G.

Plate 15, fig. 1

Cells spherical, 40–60μ diam., embedded within the host on both sides; chromatophore, single, at first small, covering the upper part of the young plant, then increasing in size by sending out several radiating arms and finally covering the cell wall; pyrenoid, single, large, embedded within the chromatophore toward the upper part of the cell; cell wall 2–3μ diam., hyaline, not laminated; color, grass green; sexual reproduction by 2-ciliated isogametes, 3–4μ diam., fusiform to almost spherical, escaping singly through the oval opening in the outer wall; asexual reproduction by zoospores and akinetes unknown.

Growing completely embedded within the outer membrane of *Porphyra perforata* f. *segregata* Setchell and Hus. Washington (Cape Flattery) to central California (San Francisco).

Setchell and Gardner, *in* Gardner, New Pac. Coast Mar. Alg. I, 1917, pp. 379–384, pl. 32, f. 6; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2280.

This species was discovered at Lands End, San Francisco, California, but since the first publication of its discovery it has been observed in the vicinity of Cape Flattery, Washington, where it grows in abundance on the same host as at San Francisco. It probably extends along our coast wherever the host plant grows.

A full account of the morphology and development of this species, as well as an extended discussion of the status of *Chlorochytrium* and the various plants referred to *C. Cohnii*, will be found under the reference to Gardner given above.

3. **Codiolum** A. Braun

Frond unicellular, ovoid to clavate or subcylindrical, the cell wall prolonged below into a longer or shorter stipe, attached by a simple or forked expansion; chromatophore covering the cell wall or more or less broken, with several pyrenoids; asexual reproduction by 4-ciliated zoospores, many in a cell.

A. Braun, Algarum Unic., 1855, p. 19.

This genus was first mentioned in 1852 by Braun before the 29th Congress of naturalists and physicians at Wiesbaden (cf. Flora, 1852, p. 755) and was excellently described and illustrated in full in 1855 in his "Algarum Unicellularum Genera nova et minus cognita" (p. 19). The type species is *Codiolum gregarium* A. Braun, and the type locality is Helgoland.

The species of *Codiolum* are all very similar and consist of a colorless stipe of longer or shorter dimensions bearing above a swollen cell which is elongated ovoid in shape and which is termed the "clava." The dimensions of both stipe and clava differ somewhat even in the same species, but in the endophytic species the stipe may be abbreviated or even, most commonly, wanting.

Key to the Species

1. Cells with a long stipe not endophytic.....1. **C. gregarium** (p. 151)
1. Cells with stipe short or wanting, endophytic.....2. **C. Petrocelidis** (p. 152)

1. **Codiolum gregarium** A. Braun

Plate 15, fig. 2

Clava narrowly elliptical in median section, definitely delimited from the long narrow stipe, up to 500μ long, and 100μ wide; stipe hyaline, unbranched, nearly cylindrical but slightly enlarging upward, 600–1000μ long, 20–30μ wide, somewhat disk-shaped at the base.

Reported from a single locality in our region, growing on an iron buoy near Friday Harbor, San Juan County, Washington.

A. Braun, Alg. Unic., 1855, p. 20, pl. I, f. 1–17; Collins, Green Alg. N. A., 1909, p. 152.

There have been described several species of *Codiolum* beside the endophytic species and these species have been dependent largely upon differences in various dimensions, but particularly on length of stipe. Börgesen, however, in his "Marine Algae of the Faeröes" (1902,

p. 517) comes to the conclusion that two species, or groups of species, stand out with fair distinctness, viz., *Codiolum gregarium* A. Braun, in which species (or group) the clava is definitely constricted at the line of union with the stipe, and *C. pusillum* (Lyng.) Kjellman, where the stipe passes insensibly into the clava. Our specimens are to be arranged with *C. gregarium* A. Braun and while their dimensions differ from those given by various authors for this species, yet it seems best not to attempt any separation at present. Our specimens vary in length of clava from 160μ to 240μ, and in width from 32μ to 64μ, while the stipe varies from 250μ to 550μ in length and from 16μ to 28μ in diameter.

2. **Codiolum Petrocelidis** Kuckuck

Clava ovoid or obovoid, 65–90μ long, 20–30μ wide; stipe relatively short or sometimes absent, often tapering abruptly below into a sharp point.

Growing within the thallus of *Petrocelis franciscana,* central California, and of *P. Middendorffii,* Whidbey Island, Washington.

Kuckuck, Bemerk. zur mar. Algenveg. Wiss. Meeres., vol. 1, 1894, p. 259, f. 27; Collins, Green Alg. N. A., 1909, p. 152; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2281. *Chlorochytrium Schmitzii* Setchell and Gardner, Alg. N. W. Amer., 1903, p. 206 (in part).

Codiolum Petrocelidis was described by Kuckuck from specimens growing in *Petrocelis Hennedyi* at Helgoland, where it had first been detected many years previously by Ferdinand Cohn. It has also been described as growing in *Petrocelis* on the coast of New England. Two specimens of *Codiolum* growing in species of *Petrocelis* have been collected on the Pacific Coast of North America, one in *P. Middendorffii* on the west coast of Whidbey Island, Washington, and the other in *P. franciscana* on the coast of central California at Fort Point, San Francisco. These two sets of plants differ somewhat from one another and also both differ in dimensions from *C. Petrocelidis* as described by Kuckuck. Kuckuck gives (as in description above) 65μ to 90μ long and 20μ to 30μ wide as the dimensions of his type. The Washington plant varies from 136μ to 180μ long and from 20μ to 44μ wide for the clava, while the Californian plant shows clavae from 80μ to 140μ long and 28μ to 42μ wide. It seems best, however, to refer them both to *Codiolum Petrocelidis* Kuckuck, at least for the present.

As to the stalk (or stipe) it is very distinct in some specimens while absolutely wanting in most of the others, but the shape of the cell is, in general, sufficiently distinctive to permit of the ready separation of these specimens from those usually referred to *Chlorochytrium*.

Order 2. SIPHONALES (grev.) oltmanns

Fronds filamentous, either simple or variously entangled or interwoven, sometimes producing complex individuals, devoid of septa (or very nearly so) in the actively vegetative portions, but septa appearing in the reproductive portions, multinucleate and with many small chromatophores; multiplication vegetative, by non-sexual spores, and by zygotes; vegetative by abscission of proliferous shoots or fragmentation; non-sexual spores, either aplanospores or zoospores, produced usually in specialized zoosporangia; zygotes from either isogametes or heterogametes.

Siphonales Oltmanns, Morph. und Biol. d. Algen, vol. 1, 1904, pp. 134, 291; Blackman and Tansley, Revis. Class. Green Algae, 1902, p. 114; Collins, Green Alg. N. A., 1909, p. 385; West, Algae, vol. 1, 1916, p. 222. *Siphoneae* Greville, Alg. Brit., 1830, p. 183.

There is a very considerable variety both in the structure of the frond and in the methods of multiplication to be found among the Siphonales. From the simple globular but pedicellate *Halicystis* or the dichotomously filamentous *Vaucheria* or *Derbesia*, through the more or sometimes less specialized species of *Bryopsis*, to the elaborately constructed fronds of the Codiaceae, which are, however, made up of interwoven filaments with or without calcareous incrustation, there is a series of increasing complexities. In sexual multiplication there is also a series of increasing complexities from the isoplanogametes of *Bryopsis* through the heteroplanogametes of *Codium* to the condition in *Vaucheria*, where the female gamete is large and motionless and the male gamete is small and motile. Complexity of form and differentiation of gametes do not proceed along the same lines, e.g., *Vaucheria* has a frond of simple structure, while its male and female gametes are most widely different from one another.

Key to the Families

1. Thallus filamentous 2
1. Thallus not filamentous ..... 3. **Protosiphonaceae** (p. 154)
2. Filaments free 3
2. Filaments densely interwoven to form a complex thallus ..... 6. **Codiaceae** (p. 166)

3. Filaments pinnately branched.....4. **Bryopsidaceae** (p. 156)
3 Filaments irregularly or dichotomously branched..... 4
4. Sexual reproduction anisogamous; zoospore single, covered with cilia.....
.....7. **Vaucheriaceae** (p. 177)
4. Sexual reproduction unknown; zoospores several in a sporangium, provided with a crown of cilia.....5. **Derbesiaceae** (p. 163)

FAMILY 3. PROTOSIPHONACEAE BLACKMAN AND TANSLEY

Thallus small, more or less globular, with or without colorless rhizoids or pedicels, unseptate in vegetative condition; nuclei several; chromatophore single and reticulate, or several, with or without pyrenoids; multiplication vegetative, by aplanospores, through micro- and macro-zoospores, and possibly also through isoplanogametes.

Blackman and Tansley, Rev. Class. Green Alg., 1902, p. 115; Collins, Green Alg. N. A., 1909, p. 153; West, Algae, vol. 1, 1916, p. 223.

A small family separated by Blackman and Tansley from the Botrydiaceae to contain particularly *Protosiphon* Klebs as a segregate from *Botrydium* Wallroth which, in turn, was removed from the Isokontae to the Heterokontae. Besides *Protosiphon*, it is usually made to include *Blastophysa* Reinke and *Halicystis* Aresch. The result is a not over homogeneous assemblage and one not readily or satisfactorily to be defined. Our only representative is *Halicystis ovalis* (Lyngb.) Aresch, which is described further on.

4. **Halicystis** Aresch.

Thallus globular to ovoid, unseptate, multinucleate, with penetrating rhizoidal portion; chromatophores small, disk-like, destitue of pyrenoids; asexual reproduction by 2-ciliated zoospores without stigma, escaping through one or more openings; similar but smaller zoospores or zoogametes(?) formed in separate individuals; after the emission of the spores the openings close and several new generations of spores can be similarly produced.

Areschoug, Phyc. Scand., part II, 1850, p. 446; Collins, Green Alg. N. A., 1909, p. 372.

A genus of two marine species of the northern oceans, seemingly occurring in both the north Atlantic and the north Pacific. It has been separated from *Valonia* because the vegetative body consists of an unseptate coenocyte of an ovoid shape with short pedicel and

rhizoidal portion. It is now placed near to *Protosiphon,* which it more closely resembles than any other genus. The description given above is adapted from Collins (*loc. cit.*) and expresses well the general characters.

Halicystis ovalis (Lyngb.) Aresch.

Plate 14, fig. 3

Thallus solitary or gregarious, obovate-ovoid, 0.5–1 cm. high, about half as wide; membrane tough, 10–12μ thick; basal prolongation penetrating the substratum; zoospores 12–14μ long, 7–8μ wide; gametes (?) 7–8μ long, 2–3μ wide.

Growing on *Lithothamnion* and on other crustaceous corallines adhering by means of the rhizoidal portion penetrating deeply into the host. Vancouver, British Columbia, to Monterey, California.

Areschoug, Phyc. Scand., part II, 1850, p. 447; Kuckuck, Abhandl. Meeresalg., 1907, p. 139, pl. III; Collins, Green Alg. N. A., 1909, p. 372. *Valonia ovalis* (Lyngb.) Agardh, Sp., vol. 1, part 2, 1822, p. 431; Saunders, Four Siphon. Alg., 1899, p. 2, pl. 350, f. 2 a, b; Setchell and Gardner, Alg. N. W. Amer., 1903, p. 232. *Gastridium ovale* Lyngbye, Hydr. Dan., 1819, p. 72, pl. 18 B.

This very curious and interesting species has been most carefully studied, described and illustrated by Kuckuck (1907) and seems to be the same as that found on our own coast. Very little material is available for study, neither of the present writers has had the opportunity of collecting it, and only one of them (Setchell) has had the privilege even of examining a living plant. In general appearance and structure, however, the Pacific Coast plant agrees thoroughly with the descriptions of the European writers.

It was first credited to our coast by Saunders (1899) who found it at "Point Lobos" (or Point Carmel) in Monterey County, California. Later it was found in successive years at a locality near Point Cypress, only a few miles north of "Point Lobos" by Professor Harold Heath of Stanford University, and the third and last locality is Port Renfrew in British Columbia, where it was collected by Misses Butler and Polley. It is always found growing on living crustaceous corallines into the thallus of which it bores its way. It will probably be found at other points along the coast, since it undoubtedly escapes observation as it is small and grows at, or just below, the lowest tide mark.

family 4. BRYOPSIDACEAE (bory) de-toni

Thallus a more or less branched, unseptate coenocyte, arising from rootlike, creeping, often rhizome-like filaments which originate as lowermost branches; branching more or less regularly or irregularly pinnate and lateral pinnules of definite growth arranged pinnately, and either distichous or polystichous, never interwoven; wall thin, neither incrusted nor provided with trabeculae (as in the Caulerpaceae); chromatophores and nuclei numerous and small, the former elliptically discoid and provided with a single pyrenoid each; vegetative reproduction by a detachment of pinnules or breaking off of proliferations or the creeping rhizome; zoospores unknown; sexual reproduction by 2-ciliated anisogametes produced in gametangia which are slightly modified pinnules (*Bryopsis*) or ovoid or pyriform outgrowths from the pinnules (*Pseudobryopsis*); monoecious or dioecious; female gamete the larger, with large posterior chromatophore, male gamete smaller, brownish-red with reduced chromatophore; zygote germinating at once.

Bryopsidaceae De-Toni, Syll. Alg., vol. 1, 1889, p. 427; Collins, Green Alg. N. A., 1909, p. 402; West, Algae, vol. 1, 1916, p. 225. *Bryopsideae* Bory, Voyage Coquille (Duperrey), Bot., 1828, p. 203; Thuret, Rech. sur les zoosp. et les antherid. des Crypt., 1850, p. 217 (*sub* "Bryopsidees").

The genus *Bryopsis* is the only representative of the family Bryopsidaceae on our coast. The family closely resembles the Derbesiaceae, from which it is distinguished by its method of branching and the possession of 2-ciliated, motile, reproductive bodies, the Codiaceae, from which it is distinguished by not having its branches interwoven to form a complex frond, and the Caulerpaceae, from which it is distinguished readily by the thin wall and lack of internal reënforcing plates or trabeculae. The fernlike fronds of our species distinguish them at a glance from all our other filamentous Chlorophyceae.

The name Bryopsidaceae, as first used by Bory, included other Siphonales as well as *Bryopsis,* particularly species of *Caulerpa* and *Vaucheria.* The present concept of the family dates from about 1850 when Thuret published his classic paper on zoospores and antheridia.

The account of the reproduction is adopted from Oltmanns (1904, p. 304 *et seq.*) and has not been verified, as yet, in our species.

5. **Bryopsis** Lamour.

Thallus unseptately coenocytic, much branched; chromatophores numerous small disks, each with one pyrenoid; the axis producing rhizoids below and branches above both of unlimited and limited growth; in the latter large, 2-ciliated, green, female gametes, and on separate individuals, smaller, brown, 2-ciliated male gametes are formed; by the union of the two a zygote is formed germinating immediately.

Lamouroux, Observ. sur la physiol. des alg. mar., 1809, p. 333, Mém. sur trois nouv. gen. de la famille des alg. mar., 1809*a*, p. 133; Collins, Green Alg. N. A., 1909, p. 402.

The above description, taken largely from Collins, expresses the technical characteristics of the family and of the genus *Bryopsis*. In this genus the gametes are produced in the branchlets of limited growth which are little changed, but are shut off from the axis on which they are borne when they are transformed into gametangia. The genus contains about twenty-five species and inhabits warmer waters, but a few species proceed northward into decidedly cold water, e.g., *B. plumosa* (Huds.) J. Ag. being credited even to the icy waters of Baffin Bay. Most of the species have wonderfully symmetrical fern-like fronds of a beautiful dark green which, when spread out on paper, adhere closely to it and produce a very pleasing picture. Our Pacific Coast species are nowhere common, and are in need of more careful study to determine their habits of growth and reproduction, as well as their specific differences and identities.

The species of *Bryopsis* present problems of determination of exceeding complexity and difficulty. The specific limits do not seem to be at all well ascertained and the actual identity and limits of the described species must remain uncertain until some monographer, with ample facilities and patience, shall have unusual opportunities for study and illustration. Much remains to be determined as to the stability of the various characters of these plants. A preliminary study leads us to believe that many characters, even of minor morphological importance, may prove stable and suitable for use in distinguishing species. The general habit, the number of orders of branching, the distinctness or lack of it of the "plumes," or feather-like divisions, the distichous, tetrastichous, or polystichous arrangement of the ultimate branchlets, or "pinnules," are characters now generally employed. We suggest also comparison of the exact shape and

proportions of the pinnules and, especially, the shape of the bases of the older pinnules, as important characters. The bases of branches and branchlets, especially below on the main or secondary axes, may produce rhizoid-like, almost corticating, structures, and these seem to present differences, possibly of diagnostic value. M. A. Howe has particularly called attention to this in his "Marine Algae of Peru" (1914, p. 38 *et seq.* and pl. 7, f. 6–9). They were also made part of the distinction in *B. corticulans* Setchell, but they exist in many, or possibly all, species, varying in their shape and distribution.

Key to the Species

1. Thallus small, more or less simple.....1. **B. pennatula** (p. 158)
1. Thallus 8–14 cm. high, much branched..... 2
2. Pinnules arising on all sides of the branches.....2. **B. hypnoides** (p. 159)
2. Pinnules distichous..... 3
3. Base of pinnules abruptly constricted and unequally rounded.....3. **B. corticulans** (p. 160)
3. Base of pinnules gradually tapering and not appreciably rounded.....4. **B. plumosa** (p. 161)

1. **Bryopsis pennatula** J. Ag.

Thallus more or less simple, sublinear in outline, distichously pinnate; pinnules nearly equally long, cylindrical, obtuse.

Known only from the type locality "St. Augustin," on the Pacific coast of Mexico, where it was collected by Professor Liebmann of Copenhagen.

J. G. Agardh, Nya alger från Mexico ("Algae Liebmannianae"), 1847, p. 6; Kuetzing, Spec. Alg., 1849, p. 492, Tab. Phyc. vol. 6, 1856, p. 27, pl. 76, f. II. *Bryopsis pennata* var. *minor* J. G. Agardh, Till Alg. Syst., 1886, part 5, p. 23. *Bryopsis pennata* Collins, Green Alg. N. A., 1909, p. 405 (in part).

The only information available concerning this species is derived from Agardh's description and Kuetzing's figure. The latter seems to have been drawn from a specimen of the type collection. Agardh, later, as may be seen from the references above, reduced this species to a form of *Bryopsis pennata* Lamour. Comparing figures and specimens of *B. pennata*, there seems to be a close resemblance in habit and even in the shape of the pinnules, but the Mexican plant is very small and slender, as compared with typical *B. pennata*, and it seems best to us to keep it distinct until additional collections throw further light

upon the relationships of the two plants. Concerning the type locality, which is also the type locality for other species published by J. G. Agardh in the same paper, it seems probable it is on the coast of the state of Oajaca in the vicinity of Pochutla and Pt. de Huatulco. (See Oersted in Liebmann, Chênes de l'Amerique Tropicale, 1869, p. viii.)

2. **Bryopsis hypnoides** Lamour.

Thallus 5–10 cm. high, flaccid, rather pale green, profusely and variously branched; branches in no definite order, growing smaller in the successive series, and with no sharp division between the lesser branches and the pinnules that clothe them on all sides, the latter themselves being frequently more or less branched; pinnules usually long and slender, gradually attenuate at the apices, suddenly constricted and symmetrically rounded at the bases.

Growing on logs, floats, shells, stones, etc. Ranging from Victoria, British Columbia, to San Pedro, California.

Lamouroux, Mém. sur trois nouv. genres., 1809*a*, vol. 2, p. 135, pl. 1, f. 2 a, b; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 230; Harvey, Phyc. Brit., 1846, pl. 119; Vickers, Phyc. Barb., 1908, p. 30, pl. 53, f. 1, 2; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1028.

Only three illustrations of this species are available to convey an idea of the characteristics of the species. The first, and only strictly authentic illustration, is that of Lamouroux (1809*a*, pl. 1, f. 2 a, b). Figure 2a represents the habit, while figure 2b shows the enlarged tip of a pinnule. The plant is evidently polystichous with the ultimate branchlets gradually attenuated in the lower third, or even half. The second is that of Harvey in the Phycologia Britannica (pl. 119), which does not represent the plant with sufficient detail to make as certain as desirable the shape of the base and apex of the pinnules. It is very evident, however, that the conception of Harvey was of a much branched, polystichous plant with long slender pinnules which are more or less constricted at the base and with the base itself unsymmetrical. The third illustration is that given by Anna Vickers in her Phycologia Barbadensis (pl. 53). The pinnules of this species, both as to proportions and as to branching, seem very different from those of both the others. The illustrations of the plumules (*loc. cit.*, f. 2) seem also to indicate that the gametes (?) are formed in restricted basal segments of the pinnules.

The branching of *Bryopsis elegans* Menegh. figured by Zanardini (1860–76, pl. 72) referred to by J. G. Agardh (1886, p. 28) as being possibly of *B. hypnoides* is different in detail, at least, from all the others.

The specimens from the Pacific Coast, referred here until more study and careful comparison with the type specimens can be made, seem reasonably uniform. They are much branched plants, polystichous, with less definite distinction between axes and with less regular plumes than *B. corticulans* shows. The pinnules are comparatively long and slender, long attenuate at the apex, but suddenly contracted to a broad, rounded base, and attached to the axis by a narrow neck. The older pinnules are very symmetrically rounded at the base and without any appearance of the production of rhizoidal outgrowths above, but possessing stout, rather long and branched rhizoids at the bases of the main branches (cf. M. A. Howe, 1914, p. 40, and Phyc. Bor.-Amer., no. 1028). The Pacific Coast plants referred here vary somewhat in coarseness and may ultimately be found to belong to more than one species.

3. **Bryopsis corticulans** Setchell

Plate 15, figs. 4, 5, and plate 27

Thallus rather stout and coarse, 8–14 cm. high, main stem 1 mm. diam.; dark green in the growing parts, glossy throughout; main stems not much divided, lower part naked, upper part, usually about half of the whole length, with abundant, patent, generally opposite branches constricted at the bases, naked below, above with rather stout, distichous pinnules, decreasing in length towards the tip of the branch and abruptly contracted at the unequal base; general outline of frond of individual branches pyramidal; conspicuous tufts of coarse, descending, slightly branched, rhizoidal filaments found at the bases of the branches and branchlets.

Growing on rocks in the lower littoral belt, from Vancouver, British Columbia, to southern California. Observed at Vancouver Island, British Columbia, Puget Sound, Washington, and also at Santa Cruz, Pacific Grove, Carmel, and San Pedro in California.

Setchell, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), 1899, no. 626; Collins, Green Alg. N. A., 1909, p. 404; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 230. *Bryopsis plumosa* Tilden, Amer. Alg. (Exsicc.), no. 371 (not of C. Agardh).

Bryopsis corticulans is a coarse, dark green species, fairly regularly distichous and with pinnules little reduced in size from the axis whence they spring. It has, in the older plants at least, small clusters of short rhizoidal outgrowths at the bases of the lower (or even of the upper) branches. Thus far it has been observed only in winter and spring on the coast of California, but in Puget Sound it seems to occur also in mid-summer. It is closely related to *B. plumosa,* but it is coarser, with more regularly occurring corticulating rhizoids, and with the pinnae more elongated lanceolate. It is still a question whether we have true *B. plumosa* or not, and it is not absolutely certain that *B. corticulans* differs sufficiently from it to be always distinguishable. The pinnules of *B. corticulans*, however, are coarser, more robust, and more abruptly and unequally rounded at the base than those of any of the plants usually referred to *B. plumosa.* The lower plumules are not only abruptly and extremely constricted at the base, but possess bases which bulge out on the lower side where the rhizoidal growths issue. Thus far the great majority of the strictly distichous *Bryopsis* from our coast seem referable to *B. corticulans* rather than to *B. plumosa.*

4. **Bryopsis plumosa** (Huds.) Ag.

Plate 14, figs. 1, 2

Thallus not more than 10 cm. high, deep green and shining, more or less branched once or twice, seldom more, the ultimate branches forming plumes with distichous, slender pinnules gradually narrowed above and to a base which is slightly, if at all, rounded; bases of the lower branches showing several short lobes.

On floats, Puget Sound Marine Station, Friday Harbor, San Juan Island, Washington, collected by Annie M. Hurd.

Agardh, Sp. Alg., vol. 1, part 2, 1822, p. 448; Collins, Green Alg. N. A., 1909, p. 403. *Ulva plumosa* Hudson, Flora Anglica (2nd Ed.), 1778, p. 571.

The type locality of *Bryopsis plumosa* is Exmouth in Devon on the south coast of England, and no type specimen seems to be available. The species is widespread, as far as report goes, but it is very doubtful whether by any means all the plants, even of Europe, assigned to it, really are properly referred. It is distichous, as generally defined, and has broad triangular plumes. More investigation is needed to determine exactly the original application of the name, if possible, and

also, as to how many varieties or even species are to be properly referred under it. The illustrations by Kuetzing (1856) both under *B. plumosa* (pl. 83, f. I) and under *B. abietina* (p. 80, f. I) are usually referred to *B. plumosa*. On comparing these illustrations with those of Harvey (1846, pl. 3), Greville (1830, pl. 19) and of *Bryopsis Lyngbyei* Hornemann (1818, pl. 1603) and its reproduction by Lyngbye (1819, pl. 19, f. B), it seems evident that there is considerable variety among the European plants referred to *B. plumosa*. Unfortunately the figure of *B. arbuscula* Lamouroux (1809, pl. 5, f. 1) is only of the habit of the plant.

Without opportunity of examining a distinct type, or any specimens from the type locality, it is impossible to determine with any certainty just what the *Ulva plumosa* Hudson may be. However, judging by specimens from Debray from the neighboring coast of France, it seems likely to prove to be a plant very similar to that figured by Kuetzing (1856, pl. 83, f. II), viz., a distichous plant with pinnules gradually tapering to both base and apex. This gradually tapering base of the pinnule is not found in any of our specimens of *B. corticulans* or *B. hypnoides*. It may possibly be that this is characteristic of only younger stages of the European plant, but this does not seem likely. An illustration which seems to be reasonably authoritative, and one that may serve as a basis for discussion is that of *Ulva plumosa* of the English Botany (vol. 33, 1814, pl. 2375). This seems also to be the basis for the figures of plate 19 of Greville's Algae Britannicae (1830). The agreement of these figures with that of Kuetzing is very close.

As to whether *Bryopsis plumosa* is represented on the Pacific coast of North America, or not, there is little to be said. The name appears in certain local lists and Tilden (Amer. Alg., no. 371) has distributed a plant from Tracyton, Washington, in the Puget Sound region which seems rather to be *B. corticulans* Setchell. There is a single specimen collected by Miss Hurd (Herb. Univ. Calif., no. 200726) which seems to agree fairly closely with the illustration in the "English Botany" and we refer this to *B. plumosa* with some hesitation. The shape of the pinnules seems to be fairly characteristic. In this specimen the bases of the lower branches show several short, blunt lobes. Older specimens might show that these grow out into short rhizoids such as are found abundantly in Atlantic Coast and European plants referred to this species. The description given above was drawn up with especial reference to our plant.

FAMILY 5. DERBESIACEAE (THURET) KJELLM.

Thallus of erect, simple or sparingly branched coenocytic filaments, arising from more slender creeping filaments which are attached to the substratum by short, branched, rhizoid-like holdfasts; chromatophores small, discoid, oval or elliptical in shape without or with one or two pyrenoids; non-sexual reproduction by zoospores provided with a crown, or circlet, of cilia, produced in special, lateral, globose to pyriform zoosporangia, sexual reproduction unknown.

Derbesiaceae Kjellman, Algae Arctic Sea, 1883, p. 316. *Derbésiées* Thuret, Rech. sur les zoospores des algues, etc., 1850, p. 231 (p. 22 Repr.). *Derbesieae* Thuret, *in* Le Jolis, Liste des alg. mar. de Cherbourg, 1863, p. 14.

The family of the Derbesiaceae differs from all others of the Isokontae in the possession of zoospores with a circlet of cilia similar to those of the Stephanokontae. In spite of this seemingly fundamental difference, all writers have placed it among the Isokontae rather than among the Stephanokontae. Davis, in his paper on "Spore formation in *Derbesia*" (1908), has followed out the nuclear behavior during zoospore formation and its relation to the development of a blepharoplast as well as the resulting circle of cilia. Unfortunately the development of the zoospore and of the circlet of cilia is not as yet known for *Oedogonium* or any other of the Stephanokontae. Davis (*loc. cit.*, p. 16) states that the zoospores of *Derbesia* and of *Oedogonium* are of similar structure and ventures to predict that those of *Oedogonium* will be found to develop a blepharoplast closely similar to that of *Derbesia*. Nevertheless, he warns against the danger of classifying the algae on the basis of the structure of zoospores and gametes and expresses as his idea that *Derbesia* should not be removed from the Siphonales. Davis also expresses the opinion that no one will be bold enough to suggest a relationship between *Derbesia* and *Oedogonium* on account of the resemblances of the zoospores.

It seems to us, however, that in the Stephanokontae, there exists a peculiar type which may be as early, or as primitive, as any of those under the Isokontae. Possibly there may have existed many forms of Stephanokontae, now lost, or possibly not yet discovered. We may assume then that as the Isokontae have advanced along several lines from multicellular to septate and then to unseptate coenocytic condition, the Stephanokontae may have done the same. It seems to us neither impossible, nor wholly inconsistent with what we find

among the Isokontae, to consider *Derbesia* as a coenocytic genus of the Stephanokontae. For general convenience, however, connected with the fact that this account deals with marine species only, we leave it in the place usually assigned to it.

There are only two genera to represent this family, *Derbesia* Solier and *Bryobesia* Weber-van Bosse. Of these *Derbesia* alone has been found, thus far, on our coast.

6. **Derbesia** Sol.

Filaments unseptate, or with occasional partitions, multinucleate, simple or branched, with no differentiation of axis and branches; chromatophores numerous, discoid, with or without pyrenoids; nonsexual reproduction by large, multiciliate, stephanokont zoospores, each with a single nucleus, formed in lateral globose to pyriform zoosporangia; sexual reproduction unknown.

Solier, Sur deux alg. zoosp. form. le nouv. genre *Derbesia*, 1846, p. 453 (cf. also Bot. Zeit., vol. 4, 1846, p. 497), Mém. sur deux algues, 1847, p. 158.

Little remains to be said of the genus *Derbesia* after the description of the family, since there are only two genera included in Derbesiaceae. The genus *Derbesia* was founded on *D. marina* and *D. Lamourouxii*, of which the former is given first, and may properly be considered as the type. *D. marina* Solier, however, is judged not to be identical with *Vaucheria marina* Lyngbye and is now known as *D. tenuissima* (De Not.) Crouan. The genus at present consists of eight to ten species widely distributed chiefly in tropical and subtropical waters. It differs from *Bryobesia* in having the sporangia (?) lateral. In *Bryobesia* after the terminal sporangium is emptied it is forced to one side by the continued growth of the filament beneath.

Unfortunately we have had no opportunity of studying any of our Pacific Coast species of *Derbesia* in the living condition and must draw upon the publications of others for all details.

Key to the Species

1. Filaments 50–70μ in diameter.....1. **D. marina** (p. 165)
1. Filaments 100–600μ in diameter.....2. **D. Lamourouxii** (p. 165)

1. **Derbesia marina** (Lyngb.) Kjellm.

Plate 15, fig. 3

Filaments arising from a creeping base, bright green, 50–70μ diam., simple or usually with a few lateral branches similar to the axes, continuous but with a short segment separated by partitions near the base of a branch or occasionally in the axils just above a branch, little smaller than the branch itself and about as long as broad; sporangia occupying the place of branches, ovoid to subspherical, 150–250μ long, 90–200μ broad; pedicel varying from 30–70μ in length, 30–35μ in diameter, about as long as broad; spores 20 or more in a sporangium.

Alaska to southern California.

Kjellman, Alg. Arctic Sea, 1883, p. 316 (not of Solier, fide J. G. Agardh, Till. Alg. Syst., 5th part, VIII, 1886, p. 34); Saunders, Alg. Harriman Exp., 1901, p. 415; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 230; Collins, Green Alg. N.A., 1909, p. 407. *Derbesia tenuissima* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 574. *Vaucheria marina* Lyngbye, Hydr. Dan., 1819, p. 79, pl. 22 A.

We suspect that the *Derbesia vaucheriaeformis* of Saunders (1899, p. 3, pl. 350, f. 4 a-d) from "Point Lobos" (really Point Carmel) near Monterey, California, is to be placed rather under *D. marina* as understood by J. G. Agardh. Saunders describes his species as possessing filaments from 30μ to 40μ broad and elliptical, obovate or pyriform sporangia 140μ to 200μ long and 50μ to 80μ wide. The sporangia are distinctly pedicellate but the diameter of the pedicel is not given. Judging from his figure 4a, the pedicel is one half the diameter of the filament, or 15μ to 20μ broad. The zoospores, also judging from the same figure, number decidedly more than twenty. The branching is represented as dichotomous. Saunders, also, in the Algae of the Harriman Expedition to Alaska (1901, p. 415) refers a plant from Yakutat Bay to *D. vaucheriaeformis,* but did not observe mature zoosporangia.

2. **Derbesia Lamourouxii** (J. Ag.) Sol.

Filaments arising from a creeping base, a few centimeters to 2 dm. high, 100–600μ diam., dark green, rather stiff, sometimes simple, sometimes with more or less numerous irregular branches; sporangia spherical, 300–550μ diam., sessile or on short and slender pedicels.

Southern California.

Solier, Mém. sur deux Algues, 1847, p. 162, pl. 9, f. 18–30; Collins, Green Alg. N. A., 1909, p. 407. *Bryopsis Balbisiana* var. *Lamourouxii* J. Agardh, Alg. Med., 1842, p. 18.

This species is represented in the Herbarium of the University of California by two sterile specimens collected by Mrs. E. A. Lawrence, five miles south of the boundary between southern and Lower California. It is decidedly coarser than any other of the described species of the genus.

Family 6. CODIACEAE (Trevis.) Zanard.

Thallus dark green, spongy, subspherical, applanate or erect, cylindrical, flattened, or jointed, simple or dichotomously branched, at times incrusted with lime, composed of intertwined branching filaments, the peripheral branchlets forming a palisade or pavement-like external layer; septa (diaphragms) frequent but in connection with formation of reproductive organs or in older filaments; chloroplasts parietal, small, very numerous, especially at the apices of the branches, destitute of pyrenoids; multiplication through fragmentation and by zoospores and anisoplanogametes; zoosporangia and gametangia differentiated and variously situated.

Zanardini, Sagg. di class. nat. d. Ficee., 1843 (table opposite p. 17). *Codieae* Trevisan, Prosp. fl. Eugan., 1842, p. 50, Flora, 1843, p. 465 (in part).

The family, originally separated as Spongodiées by Lamouroux (1813, p. 280 or p. 71 of repr.), has long been recognized as distinct among the Chlorophyceae. It contains the most highly differentiated of the genera of the marine Green Algae, both as to complexity of thallus and as to differentiation of the reproductive cells, its only competitors being the Dasycladaceae and the Vaucheriaceae. The thallus is made up of interwoven coenocytic filaments, the peripheral branchlets of which are distinctly and variously differentiated and combined into a distinct external layer. The sporangia and gametangia are formed from modified lateral branchlets of the coenocytic filaments and the gametes are distinctly unlike in some species at least. Many of the species are heavily incrusted with lime and are important agents in the building up of coral reefs. The majority of the species are strictly tropical but some of the species of *Codium* are to be found in subtropical, temperate, and perhaps even in frigid waters.

Key to the Genera

1. Thallus without joints or calcification ..... 7. **Codium** (p. 167)
1. Thallus with distinct joints and more or less calcified ..... 8. **Halimeda** (p. 176)

7. **Codium** Stackh.

Thallus spongy, not incrusted with lime, applanate, subspherical or cylindrical, simple or dichotomously branched, attached, dark green; medullary filaments vertically intertwined, giving rise to horizontal branchlets whose tips, swollen into "utricles," form a continuous external palisade layer; multiplication by fragmentation of the thallus; sexual reproduction through 2-ciliated anisogametes produced in gametangia situated laterally on the utricles; dioecious or occasionally monoecious.

Stackhouse, Nereis Brit., 1797, p. xvi. *Lamarckia* Olivi, *in* Olivi, Zool. Adriat., 1792, p. 258, and *in* Usteri, Ann., part 7, 1794, p. 76. *Spongodium* Lamouroux, Essai, 1813, (p. 72 repr.).

The designation of this genus presents certain difficulties. The earliest name proposed seems undoubtedly to be *Lamarckia* of Olivi (1792, p. 258 and 1794, p. 76). There are, however, several other genera dedicated to Lamarck and the generic names have been spelled in various ways. The first of these was proposed by Medicus in 1789 (p. 28), but is now regarded as a synonym of the Malvaceous genus *Sida*. *Lamarkia* of Mönch, proposed in 1794 (p. 201) is still recognized as a genus of grasses, and has been adopted by the International Botanical Congress at Vienna as a nomen conservandum (cf. Briquet, 1906, p. 73, and 1912, p. 79). *Codium* was proposed by Stackhouse in 1797 in the first edition of the Nereis Britannica (2d fascicle, p. xvi), but in the second edition (1816, p. xii) evidently abandoned in favor of "*Lemarkea.*" There is an earlier generic name, *Codia* (Forster and Forster, 1776, p. 59), still used for a genus of Saxifragaceae, and *Codiacum* of Rumphius (1743, p. 65) is still current among the Euphorbiaceae. Otto Kuntze (1891, p. 900) argues for "*Lamarckia*" as the proper designation, but *Codium*, properly diagnosed (for the period), has been in almost universal use for nearly, if not quite, a century, and has the right of way now that the status of the name of *Lamarkia* has been settled as indicated above.

The genus *Codium* contains somewhat over twenty-five described species agreeing closely in microscopic structure, but differing very decidedly in habit. Some are flat expansions, some are expanded but cushion-shaped, some are spherical and hollow, while some are either cylindrical or flattened but erect and branching. J. G. Agardh (1886, p. 35 *et seq.*) has subdivided the genus according to these differences. After habit, good characters for distinction of the species have been

sought for in the varying size, shape, proportions, and modification of the tips of the utricles. Further and more careful study in this direction, not only of plants of different species, but also of plants of varying ages of the same species is very much to be desired to determine the limits of these variabilities.

The reproduction of *Codium* is known in detail only for the European *C. tomentosum* (cf. Oltmanns, 1904, p. 301, and West, 1916, p. 241). In this species the spore reproduction is exclusively sexual. There are two kinds of gametangia giving rise respectively to larger motile 2-ciliated female gametes, and smaller but similar male gametes. Conjugation has been observed and a thick walled zygote is formed which germinates later. Nothing has been undertaken, thus far, towards the study of the reproduction of our species. Gametangia (?) have been seen, in most species credited to our coast, but further stages have not been observed.

Key to the Species

1. Thallus prostrate 2
1. Thallus erect 3
   2. Thallus applanate, flat ..... 1. **C. Setchellii** (p. 168)
   2. Thallus cushion-shaped, rounded ..... 2. **C. Ritteri** (p. 169)
3. Utricles more or less mucronate ..... 3. **C. fragile** (p. 171)
3. Utricles never mucronate 4
   4. Thallus cylindrical or flattened only below the axils 5
   4. Thallus cylindrical only at base, decidedly flattened above 6. **C. latum** (p. 175)
5. Utricles 400μ or more in maximum diameter ..... 4. **C. decorticatum** (p. 172)
5. Utricles 250μ or less in maximum diameter ..... 5. **C. tomentosum** (p. 174)

"Sponge-weed" fide Mrs. Hall - Mendocino, Cal.

1. **Codium Setchellii** Gardner

Plate 30, and plate 9, figs. 10, 11

Thallus forming dense, compact, spongy, irregular cushions, 6–10 mm. up to 15 mm. thick, adhering firmly to rocks; color dark glossy green; medullary filaments 12–30μ diam.; utricles variable in shape, clavate, cylindrical, or sometimes constricted below the apex, truncate or slightly rounded above, 65–75μ wide, walls thin throughout when young, the outer ends 6–16μ thick and lamellose when older; gametangia cylindrical or slightly fusiform, 300–330μ long, 45–55μ diam., growing singly on the utricles; trichomes wanting.

Growing on rocks in the lower littoral belt. Central California (possibly extending to southern California) and northward to Sitka, Alaska.

Gardner, New Pac. Coast Mar. Alg. IV, 1919, p. 489, pl. 42, f. 10, 11. *Codium adhaerens* Anderson, List of Calif. Mar. Alg., 1891, p. 217; Howe, A month on the shores of Monterey Bay, 1893, p. 63; McClatchie, Seedless Plants, 1897, p. 351; Saunders, Four Siphon. Alg., 1899, p. 2, pl. 350, f. 3 a, b, c, Alg. Harriman Exp. 1901, p. 416; Setchell and Gardner, Alg. N. W. Amer., 1903, p. 231; Collins, Green Alg. N. A., 1909, p. 387 (not of Agardh). *Codium dimorphum* Hurd, Pug. Sound Mar. Stat. Publ., vol. 1, 1916, p. 211–217, pl. 38, f. 1–13; Collins, Green Alg. N. A., Supl. 2, June, 1918, p. 88 (not of Svedelius).

Codium Setchellii represents the *adhaerens* group of J. Agardh (1886, p. 37) on our coast. For many years all the collections of this group from the Pacific Coast of North America passed under the name of *C. adhaerens* (Cabr.) Ag. Many different species, however, have been and still are referred to *C. adhaerens*, and much careful study and comparison will be necessary before they can be satisfactorily separated.

Miss Hurd (*loc. cit.*) was the first to throw doubt on the relationship of our plant with the *C. adhaerens* of the European coast. She, however, concluded from her studies that our plants, particularly from the region of the San Juan Group of Islands, Washington, are identical with *C. dimorphum* Svedelius (plate 9, figs. 7, 8) from West Patagonia. A careful study and examination of authentic material show sufficiently constant differences between that species and our plants to seem to make it necessary to consider ours distinct from that species and from the European *C. adhaerens* as well. It has consequently been described as new by Gardner (*loc. cit.*), its type locality being Monterey, California, since from that general locality only have fruiting specimens been collected. It is highly desirable that material be studied at different seasons throughout its range and fruiting material found with a view of determining whether we have one or more species on our coast.

2. **Codium Ritteri** S. and G.

Plate 16, fig. 5

Thallus spongy, globose when young, becoming flattened, expanded and variously lobed when older, 1.5–2.5 cm. thick, attached by a broad base; the center and lower portion consisting of tortuous, loosely interwoven, rhizoidal filaments, 50–65μ diam.; utricles clavate, usually branching, rarely swollen in the middle and fusiform, mostly truncate,

150–250μ, up to 400μ diam.; 2–4 mm. long, end wall slightly thickened and with a small depression in the center; gametangia unknown.

Growing on rocks in the lower littoral and upper sublittoral belts. Extending from Kadiak Island, Alaska, to the west coast of Vancouver Island, British Columbia.

Setchell and Gardner, Alg. N.W. Amer., 1903, p. 231, pl. 17, f. 8–11. *Codium adhaerens* Tilden, Amer. Alg. (Exsicc.), no. 370 (not of Agardh).

The type specimen is a small plant about three centimeters in diameter, or possibly it may be a small lobe of an old thallus that had become loosened at the base and by wave action had been torn from the remainder of the thallus. Since the publication of the species, excellent material, several inches across, has come from Alaska to the Herbarium of the University of California through the courtesy of T. C. Frye and G. B. Rigg. These show that the species is considerably expanded and variously lobed, though not adhering so firmly and closely to the rock as do other incrusting forms of this genus. The utricles in the upper portion away from the margin are relatively much longer and narrower than those figured for the type (Setchell and Gardner, *loc. cit.*).

New utricles arise from the older one by lateral branching, as many as four and five appearing at a time. The point of origin remains constricted, and a plug cuts off the new utricular protoplast from the old one. In due course these branches may drop off, the old utricle continuing to grow, and later giving rise to others. From their bases the new utricles give rise to several rhizoidal filaments. The species probably fruits in the winter, since all the material thus far collected is sterile, and the collections have all been made in the summer.

Setchell and Gardner (*loc. cit.*, p. 232) suggested that possibly the plant distributed by K. Okamura (Algae Japonicae Exsiccatae, no. 49) under *C. mamillosum* belongs under *C. Ritteri.* Okamura (1915, p. 152) dissents from this suggestion. Since having had opportunity for further study of *C. Ritteri,* reëxamination of the Japanese plant leads us to conclude with Okamura that his plant is not the same as *C. Ritteri,* but we do not agree with him that it is the same as *C. mamillosum* of Agardh.

We have not seen the specimen of *Codium mamillosum* of Coville and Rose (1898, p. 353) from Preobrazhenskoye, Copper Island, in the Commander Group, Siberia, but, on account of the low tempera-

ture of the water at that point, we suspect that their plants may belong rather to *C. Ritteri* than to *C. mamillosum* which is a subtropical species.

"Sponge-weed" as called in California

3. **Codium fragile** (Suring.) Hariot

Plates 28, 29

Fronds one to several from a broad spongy disk, cylindrical, profusely and dichotomously branched, 25–40 cm. high, 2–10 mm. in diameter, glossy, dark green, finely rugose on the surface or, at times, densely tomentose with long hyaline hairs; utricles cylindric clavate, 150–350μ (occasionally 630μ) in maximum diameter, and 5–10 times as long as broad, provided (at least when young) with a more or less distinct mucro; gametangia (♀ ?) fusiform, 1–3 to each utricle, 250–450μ long and 75–150μ in diameter.

Growing on exposed rocks and in small pools in the littoral belt. Alaska to Mexico.

Hariot, Algues du Cap Horn, 1889, p. 32; De-Toni, Phyc. Japon. Novae, 1895, p. 64. *Acanthocodium fragile* Suringar, Algarum Japonicaeum, Index praec. 1867, *ibid.*, Hedwigia, vol. 7, 1868, p. 55; Algae Japonicae, 1870, p. 23, pl. 8; *ibid.*, Hedwigia, vol. 9, 1870, p. 133. *Codium mucronatum* J. Agardh, Till. Alg. Syst., 5th part, 1886, pp. 43, 44; Hurd, Pug. Sound Mar. Stat. Publ., 1916*a*, vol. 1, pp. 109–135, pl. 19–24; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 232; Saunders, Alg. Harriman Exp., 1901, p. 416. Four Siphon. Alg., 1899, p. 1, pl. 350, f. 1 a, b, c, d; Collins, Green Alg. N. A., 1909, p. 389; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 229. *Codium tomentosum* Tilden, Amer. Alg. (Exsicc.), no. 281 (not of Stackhouse).

The mucronate tip of the utricle of this plant is a prominent specific character, but this character is subject to extreme variation. J. Agardh (1886, pp. 43, 44) separated the species into three varieties based chiefly upon the character of the mucro. We have studied and compared plants from a considerable number of different localities ranging from Alaska to Mexico, and have come to the conclusion that the species cannot be split into varieties based upon that character. Single plants may be found producing mucronate tips covering the entire range of shapes, as regards thickening of the walls and acuteness of the tip, that have been used to designate the varieties. Miss Hurd (1916*a*, p. 109) made a critical study of the species as occurring

in the vicinity of the Puget Sound Marine Station, and came to the conclusion that they exhibited all the possible variations assigned to the varieties *novae-zelandiae* and *californicum*, both of which have been accredited to our coast. Cotton (1912, p. 114–119, pl. 7, 8, f. 3–5) has discussed the species as found on the coasts of Ireland and of Scotland with remarks on the varieties described by himself and J. G. Agardh.

As usually found, *Codium fragile* gives no impression of being tomentose, but occasionally plants are found which are covered with a thick coating of hairs. Miss Hurd (1916*a*, p. 114–116) has discussed the hairs on the utricles of this species in some detail, but did not find the extreme tomentose condition found by one of us (Gardner) at Redondo, California where the hairs were 2 mm. long, and so densely covering the whole plant as to make it seem as if parasitized. It seems that the conditions causing such extreme growth of hairs have not as yet been definitely ascertained (cf. Hurd, *loc. cit.*, and Oltmanns, 1905, p. 239). There is still a fertile field for observation and experimentation in this subject.

Codium fragile seems to be a widespread species. J. G. Agardh described it as occurring on the west coast of North America, in New Zealand, in Australia and in Tasmania. It has been found also in the Cape of Good Hope region and in the region of the Straits of Magellan (Hariot, 1889, p. 33, and Svedelius, 1900, p. 299) and on the coasts of Scotland and of Ireland (cf. Cotton, 1912, p. 115). This is certainly a wide distribution in widely separated waters, but at least the waters have approximately the same temperatures for certain portions of the year. It is interesting to compare in this connection *Codium divaricatum* f. *hybrida* Okamura (1915, p. 157, pl. 135, f. 17), which is suggested as being a hybrid between *C. divaricatum* Holmes and *C. fragile* (Suring.) Hariot.

4. **Codium decorticatum** (Woodw.) Howe

Thallus sparingly branched, dichotomous, up to 5 dm. or more long, usually decidedly flattened under the dichotomies; peripheral utricles obovoid to broadly clavate, thin walled throughout, obtuse, 135–520μ maximum diameter, 500–700μ long.

La Paz, Lower California.

Howe, Phyc. Studies V, 1911, p. 494. *Ulva decorticata* Woodward, Observations upon the generic characters of *Ulva*, 1797, p. 55.

Howe (*loc. cit.*) refers a plant from La Paz, Lower California, to this species, apparently with some confidence, and at the same time he selects *Codium decorticatum* as the correct name instead of *C. elongatum*. We have not seen Howe's plant, but certain questions arise as to the exact nature of *C. decorticatum* and of *C. elongatum*. The type specimen of *Ulva decorticata* Woodward (*loc. cit.*) is unknown and the type region is given as the Mediterranean Sea with the statement that the exact locality was unknown to the author. The type locality for *C. elongatum* Ag. (1822, p. 454) is Cadiz, Spain. The species is related to *C. tomentosum*, but differs in being more elongated, with fewer and longer branches, and in being more or less distinctly dilated and flattened just below the axils (or some of them). Such a plant is figured by Kuetzing (1856, pl. 96 b), but his plant came from Rio Janeiro, Brazil, a tropical locality. Bornet (1892, pp. 216, 217) has given his experience with *C. elongatum* and his attempts to ascertain the characters upon which separation could be made from *C. tomentosum*. He considered two sets of characters, viz., the extent of infra-axillary dilation and the magnitude of the utricles. Bornet decided to separate the species according to the presence or absence of dilations, and to subdivide the species with dilations (*C. elongatum*) into a variety with large utricles and one with small utricles, since this fulfilled the idea of C. Agardh and also corresponded with the geographical distribution. *Codium elongatum* with small utricles extends north along the Atlantic coast of France and to England, while *C. elongatum* with large utricles does not extend north of Cadiz. In this connection it is interesting to note again that Cadiz is the type locality of *C. elongatum*, and to note also that the type specimen of *C. elongatum* is, according to Howe (1911, p. 495), provided with slender utricles. The tropical forms referred to *C. elongatum* (or *C. decorticatum*?) have stout utricles as Kuetzing has described and figured (*loc. cit.*). We suspect that there may be two overlapping species of somewhat similar habit, but differing in utricles and in geographical distribution, represented under *C. decorticatum*. It may be that *C. decorticatum* (Wood.) Howe, being a Mediterranean species (subtropical), may finally be separated from *C. elongatum* Ag., the more northern (temperate) species which reaches its southern limit near Cadiz and Tangiers, and there intermingles with the large utricled form (*C. decorticatum?*) as Bornet has found it. Howe's plant from La Paz is described as having large utricles (up to 520μ diam.) and must therefore be arranged with the larger form of Bornet.

5. **Codium tomentosum** (Huds.) Stackh.

Thallus rather slender, much branched, 22–37 cm. high when growing in pools, 48–60 cm. high when growing in deep water, 3–4 mm. thick, cylindrical, often slightly flattened at the axis, dichotomous, surface often very tomentose, becoming smooth with age, color dark green; utricles cylindrical, small, 500–650μ long, 120–170μ (rarely to 220μ) wide, apex usually distinctly thickened, blunt; smaller utricles sometimes pointed, but never mucronate; gametangia (♀) small, 200–250μ long, 40–70μ wide; gametes 20–22μ long, 10–12μ wide.

La Paz, Lower California.

Stackhouse, Ner. Brit. (fasc. 3), 1801, p. xxiv; pl. 7; Howe, Phyc. Studies V, 1911, p. 493; Collins, Green Alg. N. A., 1909, p. 388; Harvey, Phyc. Brit., 1846, pl. 93; Vickers, Phyc. Barb., 1908, p. 22, pl. 26. *Fucus tomentosus* Hudson, Flora Anglica, 1778, p. 584.

In attempting to arrange the erect branched species of our coast with non-mucronate utricles, we are confronted with a problem of which the solution seems impossible at present. In the first place, the material available to us is slight; in the second place, the reference of the similar species of Europe and other parts of the world is not at all satisfactory; and in the third place it is impossible at present to examine the types of the hitherto described species of this group. When we add to this a lack of knowledge as to the possible variation in habit and size of utricle of the species of *Codium,* it seems sufficient to prevent us from presenting any but a tentative, and by no means satisfactory, arrangement. We have decided to refer our plants of this group under two species, viz., *C. tomentosum* (Huds.) Stackh. and *C. decorticatum* (Woodw.) Howe.

Codium tomentosum was originally described from Exmouth in Devon, on the south coast of England. The type specimen will presumably be found in the Buddle Herbarium in the British Museum, but no account has been published as to its exact nature. Cotton (1912, p. 114) has published an exact description of the Clare Island plant which, presumably, is true *C. tomentosum,* and we have adopted this in our diagnosis. We may assume that the typical form is a slender, much branched plant, of varying length, cylindrical, or often slightly flattened just below the axils and with slender utricles, "120–170μ (rarely to 220μ) wide," with apex distinctly thickened and blunt or at times pointed, but never mucronate. We have never seen a plant from our coast answering to this description. Howe (*loc. cit.*) has referred here a plant from La Paz, Lower California. He also

seems to be inclined to refer here no. 628 of the Phyc. Bor.-Amer. from La Jolla, California, which was distributed under the name of *Codium Lindenbergii* (cf. plate 31). We have examined the specimens of no. 628 in our copies of the distribution. Altogether there are three specimens available and all are much branched, rather broad (up to 1.5 cm.) plants which seem distinctly flattened. The utricles vary more than we have found to be the case in European *C. tomentosum*. In fact there is almost a "dimorphism" and the occasional larger type of utricle reaches a diameter of 150–330μ while the diameters of the smaller, somewhat differently shaped, utricles range from 45–80μ or more. The walls of both sorts of utricles may be thickened at the top, even to 28μ. The gametangia (?) are broadly fusiform and measure close to 200μ long and 100μ wide. More information is needed concerning these plants and it is hoped that further collections may be made. They do not seem to belong to *C. Lindenbergii* since they, although flattened, differ decidedly in details of branching and in breadth. The utricles of *C. Lindenbergii*, as described and figured by Kuetzing, are probably at least 250μ in maximum diameter, and in specimens distributed by Tyson (no. 55) occur up to at least 380μ in diameter, while the gametangia (?) are 200μ to 228μ long and 76μ to 95μ wide. It should be mentioned, however, that there are three flattened species described from Cape Colony, viz., *C. Lindenbergii* Kuetz., *C. damaecorne* (Bory) Kuetz., and *C. platylobium* Aresch., usually combined (cf. J. G. Agardh, 1886, p. 46) under the name of the first species, but possibly without good reason.

Bornet (1892, pp. 216, 217) discusses at length a similar problem connected with Schousboe's plants from Tangiers and refers *C. Lindenbergii* as a form with smaller utricles under *C. elongatum* Ag. More has been said of this under *C. decorticatum*.

In conclusion, we may say that we are not satisfied in referring the plant of southern California (as represented by no. 628, Phyc. Bor.-Amer.) to *C. tomentosum* and feel that it is probably an undescribed species. More experience with the living plant is needed, however, satisfactorily to determine its exact status.

6. **Codium latum** Sur.

Plate 15, fig. 6

Thallus arising from a small, spongy disk, 15–25 cm. high, or more, the lower stipitate portion cylindrical, 3–5 mm. diam., 2–3 cm. long, more or less branched and abruptly flattened into broad, di-trichotomously branched lobes rounded at the apices; lobes 2–3 mm. thick

and up to 5 cm. or more wide; utricles 500–600μ long, 50–110μ, up to 160μ, diam., nearly cylindrical when young, with a constriction just below the rounded apex, at maturity, with a decided shoulder below the constriction bearing a whorl of 4–6 hairs, membrane usually thickened at the apices, up to 25μ thick; gametangia (?) borne below the middle of the utricles, fusiform, 220μ long, 60–75μ diam., membrane thin.

Guadalupe Island, Mexico.

Suringar, Algae Japonicae, 1870, p. 22, pl. 7; Okamura, Icon. Japan. Algae, 1915, vol. 3, no. 9, p. 158, pl. 142.

The inclusion of *Codium latum* Sur., a Japanese species, in our account is based upon several specimens in the Daniel Cady Eaton Herbarium of Yale University. These specimens were collected on the shores of Guadalupe Island by E. Palmer in 1875. The specimens are nearly cylindrical and dichotomous or dichotomo-fastigiate below, but soon expand into long, broad, flattened lobes or branches. The particular character which makes the reference of these specimens to *C. latum* seem plausible, is the existence of a distinct whorl or verticil of hairs (shown in older specimens by projecting scars) a little below the broad apex of each utricle. These are distinctly represented in the illustrations of the species by Okamura (1915, pl. 142, f. 4, 6). The specimens resemble those of the *C. Lindenbergii* complex, but differ decidedly in the shape and size of the utricles as well as the arrangement of hairs upon them. The Guadalupe plants do not approximate the extremes of either length or breadth given by Okamura (*loc. cit.*) for his Japanese specimens but are very similar to the dimensions given by Suringar (*loc. cit.*).

8. **Halimeda** Lamour.

Fronds jointed, freely branching from near the base, attached by a dense mass of rhizoidal filaments usually strongly calcified except at the nodes; segments from slightly to very much flattened and expanded, flattened cylindrical, cuneate, orbicular or reniform, entire or variously lobed; medullary tissue a strand of longitudinal, slender, branched, unseptate filaments, expanding in the segments by lateral branchlets whose terminal cells (utricles) cohere more or less tightly to form a continuous layer, but unchanged, although often anastomosing, at the nodes and at the apex; reproduction by globose or ovoid sporangia (?) borne on slender filaments projecting beyond the sur-

face of segments and producing 2-ciliated zoospores (?) whose further development has not been followed.

Lamouroux, Class. Polypes, 1812, p. 186.

The genus *Halimeda* is very well marked on account of its calcified, jointed structure, most of the species are strongly calcified, but in the single species thus far detected on our coast the calcification is slight. The species are strictly tropical, occurring in abundance on coral reefs and assisting materially in their formation. Otto Kuntze (1891, p. 908) has urged the substitution of the earlier name *Opuntioides* of Ludwig (1737, pl. 138), but since *Halimeda* has been in practically undisputed use for over a century, it seems best to retain it as a "*nomen conservandum*" if necessary.

Halimeda discoidea Dec'ne

Plate 13, fig. 3

Fronds branched in one plane, up to 15 cm. high, nearly orbicular in outline, very slightly calcified, color bright green, fading on drying; segments mostly quadrangular-oblong or cuneate-obovoid, the longer axis longitudinal rather than transverse, thin, smooth; central filaments fused in twos, rarely threes, at the nodes; utricles of subcortical layer 68–175μ diam., larger than the interlocked, often fused, peripheral utricles.

La Paz, Lower California.

Decaisne, Mém. sur Corall., 1842*a*, p. 102; Howe, Phyc. Studies III, 1907, pp. 495–500, pl. 25, f. 11–20, pl. 26, Phyc. Studies V, 1911, p. 492.

Only a single species of *Halimeda* has as yet been credited to our coast and from a single locality, viz., La Paz in California Baja (or Lower California), Mexico. From this locality it is reported by Howe (*loc. cit.*), and we have also specimens collected at the same locality by Dr. and Mrs. Marchant. It is to be distinguished fairly readily from other flat, jointed species by its slight calcification and by the large rounded utricles of the subcortical layer. Other species are to be looked for along the tropical portion of our coast.

FAMILY 7. VAUCHERIACEAE DUMORT.

Filaments simple or usually more or less dichotomously branched, cylindrical throughout or with frequent constrictions, without septa, often gregarious into expanded tufted or feltlike masses, attached at first by colorless rhizoidal branches; chromatophores numerous, small,

lenticular, destitute of pyrenoids; akinetes (?) thick-walled formed within the continuity of the filaments; aplanospores large, ellipsoidal, formed at the ends of the branches; zoospores large, formed at the ends of the branches, provided with many cilia arranged in pairs with a nucleus immediately beneath each pair; sexual reproduction anisogamous; antheridia tubular, usually curved, emitting many very small uninucleated 2-ciliated male gametes; oogonia swollen, globular to ovoid, sessile or pedicellate, single or several together, producing a single large uninucleate non-motile female gamete amply provided with chromatophores, fertilized in position; monoecious or dioecious.

Dumortier, Comm. bot., 1822, p. 71, Analyse fam. pl. 1829, p. 77. *Vaucherideae* Gray, Arr. Brit. Pl., vol. 1, 1821, p. 288.

The family of the Vaucheriaceae, while simple in its coenocytic structure and form of filament, is probably the most complex in its reproduction among the Chlorophyceae. The zoospore is distinctly coenocytic, being large and covered with cilia which, however, are arranged in distinct pairs, each pair associated with its own nucleus. The male gametes, on the other hand, and the female gametes, so far as examined, possess at maturation only a single nucleus. They are very different in size and, while the female gamete or egg is non-motile, the sperms or male gametes are motile, with two equal cilia widely separated and pointing in opposite directions.

There are two genera usually included in the family, viz., *Vaucheria* with continuous and unconstricted filaments and *Dichotomosiphon* with more or less interrupted and constricted filaments.

9. **Vaucheria** DC.

Filaments continuous, without constrictions; reproduction as indicated for the family.

De Candolle, Extrait d'un rapport sur les Conferes 1801.

The genus *Vaucheria* includes both fresh-water and brackish-water species. A few are truly marine. There are both marine and brackish water species about San Francisco Bay, but careful search has as yet failed to reveal any trace of sexual reproduction in these. Without a knowledge of the details of this process, it is impossible to be certain of their identification. Specimens of this genus are better preserved for future study in formalin solution or in alcohol, since dried specimens are difficult to restore to normal appearance on moistening.

Otto Kuntze (1891, p. 926) raises the query as to whether *Vaucheria* DC. or *Ectosperma* Vauch. is the older name. We are unable to settle this question.

Order 3. SIPHONOCLADIALES (~~Blackman and Tansley~~) Oltmanns

Thallus usually of abundantly branched filaments, or of slightly branched sacks, septate, divisions multinucleate; chromatophores single and reticulate or numerous and lenticular; sexual reproduction by isoplanogametes.

Oltmanns, Morph. und Biol. der Algen, vol. 1, 1904, p. 134. *Siphonocladeae* Blackman and Tansley, Class. Green Algae, 1902, p. 119.

The order Siphonocladiales consists of plants with septate coenocytes, thus differing from the Siphonales which have unseptate coenocytes and from the Ulotrichales whose filaments are made up of cells in the restricted sense. Siphonocladiales are large, richly branched, filamentous species, although a few are unbranched or branched only slightly, while some species are sack-shaped with few and short segments separated from the main portion of the plant. The larger number and more complex families of this order are tropical and marine, but some families are well represented in fresh water also, and in extra-tropical as well as in tropical waters. Almost nothing is known of the tropical forms of our coast.

The recognition of the group of septate coenocytes among the Chlorophyceae as separate from the group of unseptate coenocytes, is due to Schmitz (1878, 1879, p. 273), who designated it as family Siphonocladiaceae. The placing of this group as a subseries (?) and as being made up of separate families is due to Blackman and Tansley as quoted above, although the content was not exactly coincident with that now generally assigned to the order. Although the idea of a separate group originated with Schmitz, Blackman and Tansley were the first to view it as practically a suborder of Siphonales and as made up of families.

Family 8. CLADOPHORACEAE (Hass.) De-Toni (ampl.)

Fronds of simple or branching monosiphonous filaments, free or more or less united laterally; septa frequent, enclosing segments with few to many nuclei; chromatophores broad, reticulate or polygonal-lenticular, but arranged in a network and at times connected by slender strands; multiplication by fragmentation and by akinetes; reproduction by 4-ciliated (or possibly 2-ciliated) zoospores and by 2-ciliated isogametes, formed in segments slightly, if at all, differentiated.

De-Toni, Syll. Alg., vol. 1, part 1, 1889, p. 264. *Cladophoreae* Hassall, Brit. F. W. Algae, vol. 1, 1845, p. 213.

The family of the Cladophoraceae is understood in various ways, but it has seemed best to understand it in the sense used by Oltmanns (1904, p. 255) and by Collins (1909, p. 321). It includes all the forms of the strictly filamentous Siphonocladiales which are either simple or, if branched, have branches which are septate at their bases, usually with no distinct main axis in the branched forms, and with all axes of indefinite growth. Thus we include *Microdictyon, Boodlea* and *Anadyomene.* Possibly *Struvea* also should be included in this family but it has a very distinct main axis and lateral axes of definite growth. In these respects *Struvea* resembles the Dasycladaceae, but it differs from the members of this family in its lack of calcification and of specialized zoosporangia (or gametangia) while it differs from the members of the Siphonocladiaceae (in the narrower sense) by having septa at the the bases of the branches. In *Cladophoropsis,* there occur more or less basal septa, but more frequently they are absent. We have followed West (1916, p. 305) in referring *Gomontia* to the Ulotrichales.

Key to the Genera

1. Filaments simple 2
1. Filaments branched 6
2. Filaments usually stiff or rigid 3
2. Filaments flaccid 5
3. Filaments large, over 100μ diam. ..... 12. **Chaetomorpha** (p. 198)
3. Filaments smaller, under 100μ diam. 4
4. Filaments attached ..... 12. **Chaetomorpha** (p. 198)
4. Filaments unattached, prostrate ..... 10. **Rhizoclonium** (p. 180)
5. Filaments attached ..... 11. **Hormiscia** (p. 187)
5. Filaments unattached, prostrate ..... 10. **Rhizoclonium** (p. 180)
6. Branches free 7
6. Branches anastomosing, forming a network ..... 15. **Microdictyon** (p. 231)
7. Filaments not held together by special rhizoidal or hooked branchlets ..... 13. **Cladophora** (p. 207)
7. Filaments held together by special rhizoidal branchlets or by hooked branchlets or by both ..... 14. **Spongomorpha** (p. 220)

10. **Rhizoclonium** Kuetz.

Filaments usually prostrate, or slightly ascending, of a single series of segments, unbranched, or occasionally slightly branched, with few to many rhizoidal branchlets composed of one to few segments; segments with one to several nuclei (rarely one) and a single reticulate, parietal chromatophore with numerous, more or less regularly spaced,

pyrenoids; multiplication by fragmentation and by akinetes; reproduction by 2-ciliated zoospores with stigmata; gametes unknown.

Kuetzing, Phyc. Gen., 1843, p. 261, Ueber syst. Eintheil. der Algen, 1843*a*, p. 75 (nomen nudum).

The genus *Rhizoclonium*, as founded by Kuetzing but without special indication of type species, is one of the simplest of the Cladophoraceae. It consists ordinarily of species with simple, unbranched filaments whose segments are provided with comparatively few nuclei. The rhizoidal branches may, or may not, be readily found. In the absence of these it is sometimes difficult to be certain of the genus. The species may usually be distinguished from *Chaetomorpha* by their characteristically cylindrical, never swollen, segments with a smaller number of nuclei in each, as well as by their different texture and tendency to a horizontal habit. The branched species resemble *Cladophora*, but the branches push aside the main axis and continue the direction of the main filament. The species of *Rhizoclonium* inhabit both the fresh and the salt waters.

The separation of the species of *Rhizoclonium* one from another presents certain difficulties which are increased by the fact that very little seems to have been done in the culture of species of this genus. The following characters have been considered: (1) color, (2) texture, (3) straightness or crispate character of the filaments, (4) diameters of the segments, (5) proportions of length to breadth of the segments, (6) varying thickness of the walls of the segments, (7) varying number of nuclei in the segments, (8) presence or absence of long (true) branches, and (9) presence or absence of rhizoids. Of these characters, it seems from our present imperfect knowledge that 1, 2, 3, 8 and 9 are the more dependable characters, and that 4, within certain limits, is very helpful. Characters of 5, 6, and 7 will vary within wide limits in the same plants, according to whether they are actively dividing or passing into a quiescent condition, as one of us (Gardner) has experienced in growing *Rhizoclonium lubricum* in the laboratory, and as Brand (1908, p. 66) has stated as the results of his cultures.

The principal account of *Rhizoclonium* of more recent years is that of Stockmayer (1890), but his arrangement of the marine species is not satisfactory to most students. The general disposition of the marine species made by Rosenvinge (1893, p. 911 *et seq.* and 1894, p. 126–129) seems based on more certain characters and has been generally followed. F. Brand (1908, p. 45 *et seq.*) has made some important studies through cultures, testing certain of the characters

mentioned above as to their constancy or variability. After considering all the data possible it has seemed best to take a somewhat narrower view of specific limits than has been prevalent and divide our west coast plants among five seemingly distinct species.

Key to the Species

1. Filaments flaccid or lubricous, straight or flexuous, light or yellowish green..... 2
1. Filaments rigid, contorted, dark green.....5. **R. tortuosum**.. (p. 185)
2. Layer fleecy, filaments flexuous, 10–35μ..... 3
2. Layer lubricous, filaments straight, 25–50μ .....4. **R. lubricum** (p. 185)
3. Rhizoidal branches frequent, often 2–3 septate.....1. **R. riparium** (p. 182)
3. Rhizoidal branches scarce, when present non-septate..... 4
4. Filaments 10–14μ.....3. **R. Kerneri** (p. 185)
4. Filaments 20–30μ.....2. **R. implexum** (p. 183)

1. **Rhizoclonium riparium** (Roth) Harv.

Filaments pale green, expanded on the substratum, flexuous, intertwined into a fleece; segments 20–25μ diam., rarely slightly greater or smaller, usually once or twice as long as broad; branches and rhizoids frequent, often 2–3-septate.

In skein-like masses on cliffs or hard clay banks, often among other algae in the littoral belt. Alaska to central California.

Harvey, Phyc. Brit., vol. 2, 1849, pl. 238 (binomial attributed to Kuetzing); Collins, Green Alg. N. A., 1909, p. 327 (in part). *Conferva riparia* Roth, Cat. Bot., vol. 3, 1806, p. 216; Dillwyn, Brit. Conf., 1809, p. 69, pl. E. *Rhizoclonium riparium* var. *polyrhizum* Rosenvinge, Groenl. Havalg., 1893, p. 913, f. 32; Collins, Green Alg. N. A., 1909, p. 328; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2238.

There is no question in our minds that the situation as to species of *Rhizoclonium* on the Pacific Coast of North America is very similar to, if not perhaps identical with that on the Atlantic Coast of the same continent and on the Atlantic shores of Europe. There are at least two sets, or groups, of plants differing somewhat in dimension and in habit. One of these sets of forms is usually referred to *Rhizoclonium riparium* and the other to *R. tortuosum*. This would be reasonably satisfactory, if no previous conceptions existed to be considered. The two species, however, as far as names are concerned, date back to the early portion of the nineteenth century, viz., to the publications of Roth (1806) and Dillwyn (1809) respectively. Unfortunately no type specimens are available to us and we can simply follow the

custom, with such information as we may glean from the literature. The *Conferva riparia* Roth was known to Dillwyn (1809, p. 69, under no. 111) by an authentic specimen in Turner's herbarium. Dillwyn says that the English plants referred by him to Roth's species and figured under the name were treated so on authority of an authentic specimen. Dillwyn figures (*loc. cit.*, pl. E) a plant which has shortly flexuous, but not contorted, filaments and frequent rhizoidal branchlets of several segments each. Harvey (1849, pl. 238) figures a similar plant which he states is certainly that of Dillwyn, since it is drawn from a specimen belonging to Miss Hutchins (from Bantry Bay) referred to by Dillwyn. The type of *Rhizoclonium riparium* (Roth) Kuetz., then, may be properly inferred to be the variety with frequent and complex rhizoids which Rosenvinge (1893, p. 913) named var. *polyrhizum*. This is certainly a *Rhizoclonium*, being provided with the rhizoidal branches characteristic of the genus. In general the various authors agree that the diameters of the segments vary from 20μ to 35μ, but most commonly are from 20μ to 25μ.

It seems best to us to keep *Rhizoclonium riparium* as thus characterized distinct and separate from other varieties (than *polyrhizum*) usually referred to it. The var. *implexum* (Dillw.) Rosenvinge, while very similar to the type of *R. riparium* in both texture and diameter of its filaments, is to be distinguished by the scarcity and structure of the rhizoidal branchlets and is treated here as a distinct species. The *Rhizoclonium riparium* var. *validum* Foslie (1890, pp. 138, 139) is decidedly coarser than the type and is probably to be separated from *R. riparium* in the more restricted sense, although probably closely related to it.

2. **Rhizoclonium implexum** (Dillw.) Kuetz.

Filaments simple, 20–30μ (rarely 40μ) in diameter, yellowish or light green, forming a horizontal fleecy layer; segments 1.5–2.5 times as long as broad; rhizoidal branches few or wanting, when present short, non-septate and usually continuous with the segments from which they arise.

Forming fleecy masses on mud or on various objects in the littoral belt. Alaska to central California.

Kuetzing, Phyc. Germ., 1845, p. 206 (at least as to plant of Dillwyn); Batters, Alg. Clyde Sea Area, 1891, p. 230, repr., p. 8. *Conferva implexa* Dillwyn, Brit. Conf., 1805, p. 46, pl. B; Harvey, Phyc.

Brit., vol. 1, 1846, pl. 54 B. *Rhizoclonium riparium* var. *implexum* Rosenvinge, Groenl. Havalg., 1893, p. 915; Saunders, Alg. Harriman Exp., 1901, p. 414; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 222; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 976; Collins, Green Alg. N. A., 1909, p. 328. *Rhizoclonium riparium* Tilden, Amer. Alg. (Exsicc.), no. 379 (not of Roth or Kuetzing).

A plant very similar to *Rhizoclonium riparium,* but destitute of, or provided with very few and simple, rhizoids, is found on the shores of the Pacific Coast of North America. This seems to be the same as the plants from both the European and North American Coasts which have passed under the name of *Rhizoclonium riparium* var. *implexum.* The filaments are nearly the same in diameter as those of the preceding, but possibly average slightly smaller. The rhizoidal branches are often entirely wanting and in no case are really abundant. When present they alway lack septa and generally are not cut off from the segment from which they arise. The growth is generally more entangled and fleecelike than that of the preceding species. It seems best to us to keep this form, which seemingly has a wider distribution along the Pacific Coast than *R. riparium,* separate. In adopting the name of *R. implexum,* we are guided by the descriptions of others. The type specimen of Dillwyn is unknown to us, but this seems to be the plant of Harvey and possibly also of Kuetzing and Rosenvinge. Harvey evidently founded his description on Miss Hutchins's specimen from Bantry Bay which is a topotype, possibly even a cotype of Dillwyn's species. Harvey and Dillwyn give no measurements of *Conferva implexa,* but Harvey states that the filaments are about two-thirds of the thickness of those of *C. tortuosa.* The latter is probably 40μ to 70μ in diameter. Kuetzing assigns to his *Rhizoclonium implexum* a diameter of $\frac{1}{200}'''$–$\frac{1}{150}'''$ or about 11μ to 12μ, which is very much more slender than the *Rhizoclonium riparium* var. *implexum* of Rosenvinge which is described as being 20μ to 30μ (or 40μ) in diameter.

Our plants agree well with no. 142 and even with no. 190 of Wyatt's Algae Danmonienses, issued under the names of *Conferva implexa* and *C. tortuosa* respectively. No. 142 shows no rhizoids while no. 190 shows frequent unseptate rhizoids. The segments in no. 142 vary from 35μ to 45μ, while those of no. 190 vary from 22μ to 27μ. They also agree in general with no. 624 of Wittrock and Nordstedt's "Algae aquae dulcis exsiccatae," distributed under the name of *Rhizoclonium riparium* f. *valida* Foslie.

3. **Rhizoclonium Kerneri** Stock.

Filaments pale yellowish green, segments 10–14μ diam., 3–7 diameters long, free from rhizoids or branches.

Growing in loose masses in tide-pools. Victoria, Vancouver Island, British Columbia.

Stockmayer, Ueber die Algengat. *Rhizoclonium,* 1890, p. 582; Collins, Mar. Alg. Vancouver Island, 1913, p. 103.

We have not seen any specimens of this species and are including it upon the authority of Collins (*loc. cit.*). It is decidedly more slender than the other four species of *Rhizoclonium* thus far detected on our coast.

4. **Rhizoclonium lubricum** S. and G.

Plate 9, figs. 5*a*, *b*

Filaments flaccid, lubricous, straight, cylindrical throughout, 3–4.5 dm. long, pale green; segments 35–50μ, mostly 40μ diam., resting segments 4–6 diam. long, after division segments 1–2 diam. long; chromatophore a coarse, parietal network; pyrenoids small, numerous, 40–50 in resting segments; wall 2μ thick, homogeneous; rhizoids short, mere prolongations of cells, non-septate, rare; zoospores and gametes unknown.

Growing attached in mud or floating on mud flats between tides. Roche Harbor, Washington, and Berkeley and Alameda on the shores of San Francisco Bay, California.

Setchell and Gardner, *in* Gardner, New Pac. Coast Mar. Alg. IV, 1919, p. 492, pl. 42, f. 5; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2289.

This form closely resembles *R. riparium* f. *validum* Foslie, but is practically free from rhizoids, has thinner walls and larger and longer segments. From *R. implexum* it differs in having broader, straighter filaments of very different consistency, as well as, usually, longer segments. Unlike other species of *Rhizoclonium* it is very lubricous, in mass, having the consistency of a *Spirogyra.*

5. **Rhizoclonium tortuosum** (Dillw.) Kuetz.

Filaments rigid, crispate and contorted, dark green, 40–70μ diam., forming woolly skeinlike or ropelike horizontal masses; segments 1–2, up to 6 times as long as broad, wall thick, indistinctly lamellose; rhizoids short, few or, more usually, none.

On various algae in the middle and upper littoral belts. Alaska to California.

Kuetzing, Phyc. Germ., 1845, p. 205 (at least as to the plant of Dillwyn); Farlow, New Eng. Alg., 1881, p. 49; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 223; Collins, Green Alg. N. A., 1909, p. 328. *Conferva tortuosa* Dillwyn, Brit. Conf., 1805, p. 46, pl. 46; Harvey, Phyc. Brit., vol. 1, 1846, pl. 54 A. *Chaetomorpha tortuosa* Kuetzing, Spec. Alg., 1849, p. 376; Harvey, Ner. Bor.-Amer., part 3, 1858, p. 88, pl. 46 B.

Kuetzing has described two plants, both founded, in the final analysis, upon *Conferva tortuosa* Dillwyn. One of these plants he bases directly upon Dillwyn's species and refers it to *Rhizoclonium* (1845, p. 205; 1849, p. 384). It is credited by Kuetzing to the North Sea. Kuetzing gives $\frac{1}{70}'''$–$\frac{1}{60}'''$ as the diameter of his *Rhizoclonium tortuosum* which approximates 32μ to 35μ. The *Conferva tortuosa* J. Ag. (1842, p. 12) which is the *C. tortuosa* C. Ag. (1824, p. 98) and which, in turn, is founded, as to name at least, on *C. tortuosa* Dillw., is referred by Kuetzing (1849, p. 376) to the genus *Chaetomorpha* as *Chaetomorpha tortuosa* and the diameter of the filaments is given as $\frac{1}{45}'''$–$\frac{1}{40}'''$, or approximately 46μ to 56μ. It is restricted by Kuetzing to the Mediterranean and Adriatic Seas.

Dr. Anna Weber-van Bosse has kindly allowed us to examine the specimens in Herbarium Kuetzing under the names of *Rhizoclonium tortuosum* and *Chaetomorpha tortuosa*. There are three of the former, from the Faeröes, England and Cherbourg respectively. They all seem to be *R. tortuosum* in the sense in which we use the name: The specimen of *Chaetomorpha tortuosa* from the Kuetzing collection is from Nice and while it resembles fairly closely the Kuetzing specimens of *R. tortuosum*, it has much thicker walls and possibly may be found to belong to another species.

We feel convinced of the likelihood of *Conferva tortuosa* Dillw. being the coarse, crispate plant which has been described by Harvey (1846, pl. 54 A) as *Conferva tortuosa* and (1858, p. 88) as *Chaetomorpha tortuosa* and finally by Farlow (1881, p. 49) as *Rhizoclonium tortuosum*.

As we understand this species, which is not common on our coast, it forms woolly skeinlike or loose ropelike masses of a dark green color on other algae in the littoral belt of exposed coasts. The filaments are rigid, harsh to the touch and crispate or contorted. In diameter its filaments exceed those of both *R. riparium* and *R. implexum* by

one-third or more. It varies in the length-breadth proportions of the segments, and plants with longer segments have been named forma *longiarticulatum* by Collins (Phyc. Bor.-Amer. (Exsicc.), no. 1735).

11. **Hormiscia** Fries

Filaments simple, attached at the base by rhizoids developing from a few of the basal segments, either intramatrical, extramatrical or both; segments multinucleate, all above the few basal ones similar and capable of division and producing zoospores or gametes; chromatophore covering the segment wall, entire or more or less coarsely reticulate, with few to many pyrenoids; multiplication by akinetes formed by breaking up of the filaments into individual segments with thick walls, either producing new filaments or zoospores; reproduction by macrozoospores, by microzoospores and by gametes, produced many in a segment; macrozoospores obovoid, extending posteriorly into a long "tail," provided anteriorly with 4 cilia; microzoospores smaller with less obvious tail and 4 cilia; sexual reproduction by 2-ciliated (possibly in some species by 4-ciliated) iso- or hetero-gametes.

Fries, Flora Scanica, 1835, p. 327. *Urospora* Areschoug, Observ. Phyc., 1866.

The genus *Hormiscia,* as constituted by Fries, comprised two species, viz., *H. penicilliformis* and *H. Wormskioldii.* The identity of the second species is clear enough, but that of the first rests somewhat in doubt. It seems likely, however, that the *Conferva penicilliformis* Roth is, in part at least, made up of the species more recently assigned under that name as well as under that of *Urospora mirabilis* Aresch. In such case, it seems best to follow Hazen (1902, pp. 146, 147) and adopt the name *Hormiscia* Fries rather than *Urospora* Aresch.

The genus *Hormiscia,* as at present understood, includes about fifteen described species inhabiting the cooler waters of the Northern Hemisphere. The filaments are characteristically simple but occasionally may be branched. The branches are the result of injuries or, at least, of some disturbance of the normal course of development. In our own experience they are rare. Usually the branches are short and rhizoidal, sometimes occurring in pairs, but at times they are longer, with evidence in both cases of some disturbance of normal growth at the point of origin.

Hormiscia is closely related to both *Chaetomorpha* and *Rhizoclonium*. From both of these it differs particularly in the pointed posterior ends, or "tails," of the 4-ciliated macrozoospores. The determination of this character is most satisfactorily made from living specimens. It is possible, however, to be certain of it in dried specimens of the mature fruiting stages if those are properly soaked out and stained. In such specimens, it is often possible to ascertain the shape of the zoospores with the conspicuous "tail" and in some cases even to determine the number of cilia present if specimens have been preserved in formalin solution. From *Rhizoclonium, Hormiscia* differs in habit, in being attached at one end and erect, resembling *Chaetomorpha* in this respect. From *Chaetomorpha, Hormiscia* differs in texture, being more flaccid or more lubricous.

The species of *Hormiscia* resemble one another closely and are to be separated by several minor characters. Those usually employed are as follows: (1) chromatophores, (2) mode of attachment, (3) diameters of the segments, and (4) shape and proportions of the segments. Besides there are some differences in height and texture to be considered.

The chromatophores of the species of *Hormiscia* are annular, parietal, and single in the segment. They contain a larger or smaller number of pyrenoids, more or less regularly placed. Some chromatophores seem practically imperforate, some are finely reticulate with few or many small openings, while others are coarsely reticulate with few or many large openings. Some species have thin, membranaceous chromatophores, while others have thick, solid chromatophores. The characters of the chromatophore also vary somewhat according to the metabolic or reproductive condition of the segment. The study of the chromatophore of specimens which have been dried presents certain difficulties, but usually they can be swollen up sufficiently and stained (we use acid Fuchsin) to show their nature. Ordinarily it is a fairly certain matter to determine whether a chromatophore is coarsely reticulate or not. With the more finely perforate chromatophores, the difficulties are sometimes considerable. When dried specimens are mounted fresh from the water before any collapse of the protoplast has taken place, the chromatophore will swell out with water and may plainly be seen. When segments in the filament approach the reproductive condition, the chromatophore becomes less and less perforate and also thicker, finally breaking up into areolae (as seen from the surface) which precede the formation of either

zoospores or gametes as the case may be. There seems also to be a very considerable multiplication of pyrenoids at about the same time. In the following account we have described the chromatophores as well as the material allows, pending investigation of living plants.

The filaments of *Hormiscia* are attached at the base, at least at first. They are usually attached to rock or wood, but may be, in some species at least, attached to other algae. Kjellman (1897, p. 8 *et seq.*) was the first to call attention to the variety in the method of attachment of the filaments of *Hormiscia,* contrasting those of *H. penicilliformis* with those of *H. incrassata.* The differences depend upon the behavior of the rhizoidal outgrowths from the basal segments. In some species only a few of the lower segments emit rhizoids, while in others twenty or more of the basal segments may produce them. In some species the rhizoids do not emerge from the outermost walls of the filament but descend along the segments below them, still enclosed within the walls, until the very base or near it, when they may or may not emerge and become free. We have designated such rhizoids as *intramatrical.* In some species, however, the rhizoids do not descend for any considerable distance within the outer wall of the filament, but emerge at once and either extend at any angle to the filament or descend closely applied to it. Such rhizoids are designated by as as *extramatrical.* (For the terms intramatrical and extramatrical see Jónsson, 1903, p. 360.)

In diameter the filaments vary considerably, both in regard to the different species and in regard to the segments in different portions of the same filament as well as in filaments of different ages. The filaments taper from the base upwards and then often narrow again more or less towards the apex. The tapering upwards is slight in some species but more considerable in others. In most species it is gradual but in other species it is abrupt. The diameters of the reproductive segments are usually the most distinctive.

The shape and proportions of the segments, especially of the fertile segments, vary considerably among the species, but are sufficiently constant to furnish valuable characters for diagnoses. The thickness and structure of the wall, particularly of the reproductive segments, offers additional points of difference between species. The consistency of the plants, as observed in mass, varying from lubricous to fleecy, is worthy of attention, whether judged from observation of the living specimens or from the extent to which they adhere to paper in drying.

In attempting to arrange the plants of our coast, it has been

necessary to rely largely upon dried specimens or those preserved in formalin. The resulting account which follows must, therefore be regarded as tentative, but as put forth to indicate possibilities to be tested through study of living material. The tendency of two or more species to grow intermingled has often caused confusion in the past, and may have passed unsuspected in our own examinations.

As to reproductive processes, we have practically nothing new to offer from our own observations. Each species, however, should be studied in cultures to determine its correspondence with, or deviation from, the published statements for such species as have been investigated. The size and shape of the zoospores and of the gametes should be noted as well as the number of cilia present. This is especially necessary in the case of the gametes as will be noted below under *Hormiscia tetraciliata* Frye and Zeller.

In considering the specimens studied, as well as the species described, it seems possible to separate the genus *Hormiscia* into three fairly readily distinguishable sections, as follows:

Section 1. *Penicilliformes.* Segments shorter, or at most, very little longer than broad, fertile cells only slightly swollen; holdfast consisting of extramatrical, generally divaricate rhizoids, or of intramatrical rhizoids; chromatophore varying in the different species from nearly imperforate to coarsely reticulate. To this section we are inclined to refer the following described species: *H. penicilliformis* (Roth) Fries, *H. incrassata* (Kjellm.) Collins, *H. collabens* (Ag.) Rab., *H. Hartzii* (Rosenv.) Collins, *H. crassa* (Kjellm.) Collins and *H. tetraciliata* Frye and Zeller, as well as *Urospora bangioides* (Harv.) Holmes and Batt., *U. claviculata* Kjellm. and *U. acrogona* Kjellm.

Section 2. *Grandiformes.* Segments elongated, especially the fertile segments, usually twice or more as long as broad in fertile condition and not swollen; holdfast of intramatrical rhizoids (at times free at the very base) and arising from a considerable number of the lower segments; chromatophores, so far as known, coarsely reticulate. To this section we are inclined to refer *Hormiscia grandis* (Kylin) S. and G. and *Urospora elongata* (Rosenv.) Hagem.

Section 3. *Wormskioldiiformes.* Segments shorter or only slightly longer than thick, the fertile swollen to spherical or to more or less broadly or even ventricosely ellipsoidal; holdfast of intramatrical rhizoids arising from even as many as 25–30 of the lower segments and, at times, free at the very base; chromatophore from finely perforate to coarsely reticulate; coarse plants with fertile segments from

0.5 mm. to 3 mm. in diameter. To this section we are inclined to refer *H. Wormskioldii* (Mert.) Fries, *H. sphaerulifera* S. and G., and *H. vancouveriana* (Tilden) S. and G.

KEY TO THE SPECIES

1. Rhizoids extramatrical; zoosporangia not over 200μ in maximum diameter..... 2
1. Rhizoids largely or entirely intramatrical; zoosporangia 200μ or over in maximum diameter..... 3
2. Zoosporangia not over 100μ in maximum diameter..... 1. **H. penicilliformis** (p. 191)
2. Zoosporangia over 100μ in maximum diameter.....2. **H. doliifera** (p. 193)
3. Zoosporangia below 300μ in maximum diameter..... 4
3. Zoosporangia above 500μ in maximum diameter..... 5
4. Zoosporangia oblong-cylindrical, up to 175μ, or even 200μ, diameter..... 4. **H. grandis** (p. 195)
4. Zoosporangia short, barrel-shaped, up to 225μ diameter..... 3. **H. tetraciliata** (p. 193)
5. Chromatophore solid or inconspicuously perforate..... 6
5. Chromatophore coarsely reticulate .....6. **H. Wormskioldii** (p. 196)
6. Zoosporangia nearly globular, up to 700μ diameter..... 5. **H. sphaerulifera** (p. 196)
6. Zoosporangia globular to ventricose-ellipsoidal, 1 mm. to 3 mm. maximum diameter..... .....7. **H. vancouveriana** (p. 197)

1. **Hormiscia penicilliformis** (Roth) Fries

Plate 9, fig. 4

Filaments dark green, attached by extramatrical rhizoids from a few of the lower segments, 30–60μ up to 90μ diam., 0.3–2.5 times as long as the diameter; vegetative segments mostly cylindrical, fertile more or less swollen to barrel-shaped; chromatophore usually dense, a continuous parietal band, or at times somewhat fenestrate, pyrenoids relatively few and large.

Growing on rocks and timbers exposed to the surf. Alaska (Port Clarence, etc.) to central California.

Fries, Flora Scanica, 1835, p. 327; Collins, Green Alg. N. A., 1909, p. 368. *Conferva penicilliformis* Roth, Cat. Bot., III, 1806, p. 272. *Urospora penicilliformis* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 220 (in part). *Urospora incrassata* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 221 and of Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1125 (not of Kjellman). *Hormiscia incrassata* Collins, Green Alg. N. A., 1909, p. 369 (excl. syn. of Kjellman).

The exact nature of the *Conferva penicilliformis* Roth is a subject of doubt, and no one has published any statement either as to the

existenee of a type specimen or as to its nature. It seems best to retain the name for the present, however, and to assume its identity with *Conferva isogona* of the English Botany (1808, pl. 1930) whose type (cf. Batters, 1894, p. 116) is in existence and has been recently examined. There are several conflicting statements eoneerning the details of structure of *H. penicilliformis* and it seems probable that more than one speeies may be ineluded under the name. We are inclined at present to include under this name all the speeimens from the western coast of North America aeeessible to us which are under 100μ in the maximum diameter of the fertile segments. These specimens all have segments which are nearly isodiametric and with the fertile segments slightly swollen and barrel-shaped. Rosenvinge (1893, p. 918, 1894, p. 30) and Jónsson (1903, p. 360) include forms with elongated segments, but it seems probable that such forms may be referred rather to members of the section *Grandiformes*. *H. grandis* (Kylin) S. and G. sometimes occurs intermixed with *H. penicilliformis* (cf. Kylin, 1907, p. 20). The base is attached by extramatrical and divaricate rhizoids which arise from a few of the basal segments. Concerning the latter statement it is proper to call attention to the conflicting statement and figure of Börgesen (1902, pp. 500, 501, f. 100) and Jónsson (1903, p. 360). These may possibly be explained as resulting from a confusion or admixture of species. The chromatophore in our specimens shows very slight perforation at any time, being nearly imperforate. Kjellman (1897, p. 12) was among the first to call attention to the chromatophore as varying among the species. He states that the chromatophore of what he regards as true "*Urospora penicilliformis*" differs from that of "*U. incrassata*" and "*U. Wormskioldii*" in having only small openings. The general status of the nature of the chromatophore of *Hormiscia penicilliformis* has been discussed by Jónsson (1903, p. 361) who passed in review the different ideas and states that "especially in the elongated cells, the chromatophore is distinctly reticular, often with great meshes." This brings the type of chromatophore in this species near to that of *H. Wormskioldii*. We feel that it is likely that there has been a confusion of species and have restricted our idea of the chromatophore to one at most perforated with small angular openings. We have found none with large or elongated openings such as Jónsson mentions and such as Hagem (1908, p. 294, pl. 1, f. 2) describes and figures.

The Pacific Coast specimens vary from about 45μ to 90μ in maximum diameter of fertile segments but otherwise seem to agree and to be

referable to *H. penicilliformis.* Some of the specimens included here by us have been referred to *Hormiscia incrassata* (Kjellm.) Collins, but that is a somewhat larger species with a coarsely reticulate chromatophore. Some of the specimens referred by us previously (1903) to *Urospora penicilliformis* seem to us now to be placed more satisfactorily under *Hormiscia grandis* (Kylin) S. and G.

2. **Hormiscia doliifera** S. and G.

Filaments 3–4 cm. long, nearly cylindrical throughout when young, tapering only at the base, attached by extramatrical rhizoids from a few of the lower segments; color dark green; fertile segments 80–130μ, up to 184μ diam., 0.75–1.25 times as long, doliiform, with thin, 5–7μ thick, hyaline, homogeneous walls; chromatophore a thin, fenestrate, parietal band, with numerous small pyrenoids.

Growing on rocks in the upper littoral belt. San Francisco, California.

Setchell and Gardner, Phyc. Cont. I. 1920, p. 279.

Hormiscia doliifera resembles most closely *Urospora Hartzii* Rosenvinge (1893, p. 922) and *U. incrassata* Kjellman (1897, p. 7). From each of these species it differs in having filaments of larger diameter, in having more uniformly swollen, sometimes almost spherical, fertile segments, and in having the segments more nearly uniform in length, averaging a little less than quadrate. From *U. incrassata* it differs also in its strictly extramatrical rhizoids. It approaches also the little known *U. crassa* Rosenv., but its segments seem never so short as represented for that species. It is much too slender for *Hormiscia collabens* (i.e., up to 450μ) as indicated by Batters (1894, p. 114). The filaments are decidedly larger than any dimensions given for *H. penicilliformis* (Roth) Fries and the chromatophore is thinner, usually more coarsely reticulate, and with many more and much smaller pyrenoids.

3. **Hormiscia tetraciliata** Frye and Zeller

Filaments flaccid, slightly clavate, 25μ at the base, up to 220μ at the apex, 5–8 cm. long, attached by numerous intramatrical rhizoids, 1–2 from each of the lower 8–15 segments, passing out of the lower disintegrating sheath, or segment wall; segments 0.5–2 times as long as the diameter, cylindrical below, becoming decidedly barrel-shaped

above; walls up to 15μ thick, homogeneous, hyaline; chromatophore a thin, parietal, finely reticulate band, with numerous small pyrenoids.

Growing on stones, shells, and other algae. San Juan County, Washington.

Frye and Zeller, *Hormiscia tetraciliata,* sp. nov., 1915, pp. 9–13, pl. 2. *"Hormiscia Wormskjoldii"* Collins, Green Alg. N. A., Suppl. II, 1918, p. 86 (in part); Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2237.

Hormiscia tetraciliata Frye and Zeller presents a number of interesting and puzzling characters as described and figured. It seems to be a species of the *Penicilliformes* section, in that the fertile cells are short and only slightly swollen. It differs from all others of the species of that section except *H. collabens* (Harv.) Collins, in the greater maximum diameter attained by the fertile cells. Frye and Zeller give this diameter as 220μ for *H. tetraciliata* while Batters (1894, p. 114) states that *H. collabens* reaches a maximum diameter of 450μ (verified by an examination of the type specimen, *loc. cit.,* p. 115). The *Urospora bangioides* (Harv.) Holmes and Batters (cf. Batters, 1894, pp. 115, 116) seems too slender (up to 150μ, even perhaps to 180μ in maximum diameter), but the plant distributed under the name of *Urospora collabens* by Collins (Phyc. Bor.-Amer. (Exsicc.), no. 970) shows sterile segments up to 220μ in diameter and agrees closely with the description of *H. tetraciliata.* We do not find any fertile segments, however, in the Collins specimen, and the maximum diameter of the fertile segments may be much greater.

The plant distributed under no. 970 of the Phycotheca Boreali-Americana is supposed to be *H. tetraciliata* since it was collected under the supervision of Professor Frye and received his sanction. It seems to have its fertile segments rather more swollen and elongated than is indicated by the drawings of Frye and Zeller (*loc. cit.,* pl. 2, f. 6 and 17) or as provided for in the description. The distributed specimens seem rather to belong to the section *Wormskioldiiformes.* In this connection, it may also be mentioned that a later gathering, by Professor Frye, from the same locality has yielded no *H. tetraciliata,* but a mixture of what we refer below to as *H. grandis* and *H. Wormskioldii.*

The unusual character of *Hormiscia tetraciliata* is shown by the gametes. These, according to Frye and Zeller (*loc. cit.,* pp. 10, 11) have four cilia each and, judging from their figure, fuse in pairs (*loc. cit.,* f. 20) in an unusual way, i.e., not at the tips, but at the

posterior extremities. It seems possible that there may be some error of interpretation about this and Collins (1918, p. 86) suggests, with good reason, as it seems to us, that the supposed gametes may be microzoospores and that "figure 20, 'gametes fusing,' would seem rather to represent two imperfectly separated microzoospores." The matter of microzoospores and gametes especially needs further investigation in this as well as in other species of *Hormiscia*.

The holdfast of *H. tetraciliata* is, as represented by Frye and Zeller (*loc. cit.*, p. 9, pl. 2, f. 3), composed of intramatrical rhizoids arising from a considerable number of cells and simple or branched, descending within the outer wall, or sheath, of the filament, but emerging and spreading to some extent at the very base and becoming trumpet-shaped. This combination of intra- and extramatrical rhizoids seems like a combination of the characters of the species of the *Penicilliformes* section and those of the *Wormskioldiiformes* section.

4. **Hormiscia grandis** (Kylin) S. and G.

Plate 9, fig. 3

Filaments attached by intramatrical rhizoids from 8–14 segments above the base, flaccid, 8–10 cm. long; segments cylindrical, constricted at the joints, 45–70μ thick at the base, usually 2 times as long as broad, 125–175μ, up to 200μ thick at the upper end, 1–3.5 times as long as broad, walls 12–18μ thick, lamellate, fertile segments slightly swollen; chromatophore a thin, parietal, reticulate band, with numerous small pyrenoids.

Growing on rocks in the upper littoral belt. West shore of Amaknak Island, Bay of Unalaska, Alaska, to Puget Sound, Washington.

Setchell and Gardner, *in* Gardner, New Pac. Coast Mar. Alg. IV, 1919, p. 494. *Urospora penicilliformis* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 220 (in part). *Urospora Wormskioldii* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 221 (in part). *Urospora grandis* Kylin, Studien ueber Algenflora, etc., 1907, p. 18, f. 3.

In reëxamining the specimens previously referred by us (1903, p. 220) to *Urospora penicilliformis* and *U. Wormskioldii*, we found several which differed in having the fertile segments long and not swollen. They also have thick, lamellate walls. These characters agree so well with those given for *Urospora grandis* that we feel reasonably safe in referring them to that species and transferring

it to the genus *Hormiscia*. The type locality of the species is Christineberg on the west coast of Sweden, where it occurs mixed with *Hormiscia penicilliformis* and *Ulothrix flacca*. On the West Coast of North America it occurs mixed with the same species and also with *Hormiscia Wormskioldii*. It is to be compared with *Urospora elongata* (Rosenv.) Hagem but is of much greater diameter and with thicker walls in the fertile segments. The chromatophore is very coarsely reticulate.

5. **Hormiscia sphaerulifera** S. and G.

Plate 9, fig. 2

Filaments very lubricous, bright green, protoplast becoming dark when dry, 4–6 cm. long. up to 700μ diam., tapering abruptly at the base, of nearly uniform diameter above, attached by intramatrical rhizoids; segments 0.5–2 times as long as the diameter, cylindrical when young, becoming almost spherical at maturity; chromatophore a thin, unbroken band, pyrenoids small, numerous.

Growing on boulders in the extreme lower littoral belt. West coast of Whidbey Island, Washington.

Setchell and Gardner, *in* Gardner, New Pac. Coast Mar. Alg. IV, 1919, p. 493, pl. 42, f. 2. *Urospora Wormskioldii* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 221 (in part); Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 915 (not *Conferva Wormskioldii* Mert.).

In a careful study of the west coast specimens previously referred to *Hormiscia* (or *Urospora*) *Wormskioldii,* considerable differences were found which have led to their segregation among three species. The present species is the most slender of the group, reaching a maximum diameter, even in the fertile segments, of 700μ. The chromatophore seems to consist of a thin, unbroken, annular band. The fertile segments are swollen into a spherical shape and the upper portions of the filament are in the form of a necklace. The filaments are very lubricous and adhere tightly to paper.

6. **Hormiscia Wormskioldii** (Mert.) Fries

Filaments attached by intramatrical rhizoids arising from 12 to 15 of the basal segments, dark green, 10–20 cm. high, distinctly clavate; segments cylindrical below or when young, 30–60μ in diameter, increasing above in fertile segments to 500μ or even to 1 mm. in

maximum diameter; fertile segments swollen to spherico-ellipsoidal, long ellipsoidal, or even ventricose-ellipsoidal; chromatophore a coarsely reticulate, annular band.

On rocks, etc., in the lower littoral belt. Friday Harbor, Washington (*Frye*), to Gualala, California (*Brandt*).

Fries, Flora Scanica, 1835, p. 328 ("*Wormskjoldii*). *Conferva Wormskioldii* Mertens, *in* Hornemann, Flora Danica, vol. 9, fasc. 26, 1816, p. 6, pl. 1547 (not *H. Wormskioldii* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 221, and not of Collins, Green Alg. N. A., 1909, p. 368 as to Pacific Coast references and localities). *Urospora Wormskioldii* Rosenvinge, Groenl. Havalg., 1893, p. 920, f. 36.

It has been the practice to refer all the coarser species of *Hormiscia,* especially those with much swollen fertile segments, to *Hormiscia Wormskioldii.* In examining the specimens from the western coast of North America and comparing them with specimens from the type locality (Gothaab or Godthaab, on the southwestern coast of Greenland) collected in 1831 by Vahl, we find sufficient differences to make it seem best to distinguish three separate species. None of the specimens from the West Coast previously referred by us, or others, to *Hormiscia Wormskioldii* seems to us, at present, to be referable to it. We have found specimens seemingly very close to it, however, in two recent collections, as indicated above.

Hormiscia Wormskioldii is to be distinguished from the other two species we have referred to the section *Wormskioldiiformes* by its coarsely reticulate chromatophore and its intermediate size (up to 1 mm. in maximum diameter of the fertile segments). The fertile segments are usually long ellipsoidal.

7. **Hormiscia vancouveriana** (Tilden) S. and G.

Filaments attached by intramatrical rhizoids arising from 14–20 basal segments, soft, gelatinous, dark green, 10–15 cm. high, distinctly clavate; segments cylindrical when young, 75–130μ diam., quadrate, or up to 3 times as long as broad, soon becoming decidedly moniliform, the upper segments almost spherical, up to 3 mm. in diameter; chromatophore thin, very slightly if at all perforate.

Growing on stones and shells, in the lower littoral belt. On a small island east of Oak Bay, Vancouver Island, British Columbia, July.

Setchell and Gardner, *in* Gardner, New Pac. Coast Mar. Alg. IV, 1919, p. 494. *Urospora Wormskioldii* Setchell and Gardner, Alg. N.W.

Amer., 1903, p. 221 (in part). *"Hormiscia Wormskjoldii"* Collins, Green Alg. N. A., 1909, p. 368 (in part). *"Urospora Wormskjoldii* f. *vancouveriana"* Tilden, Amer. Alg. (Exsicc.), no. 381.

The plants distributed in Tilden's American Algae under no. 381 are by far the most robust of any of the genus *Hormiscia* yet seen. In several characters they resemble *H. Wormskioldii* closely, but differ decidedly in diameter and in the character of the chromatophore. The maximum diameter of the fertile segment is 3 mm. or even more. The chromatophore seems to be a close, very little, if at all, perforate ring. From *H. sphaerulifera, H. vancouveriana* differs both in its greater thickness and in the proportionally longer fertile cells.

Hormiscia vancouveriana is known only from the type locality and, as far as we are aware, from a single collecting. It is to be hoped that it may be rediscovered and studied in the living condition.

12. **Chaetomorpha** Kuetz.

Filaments composed of a single unbranched series of multinucleate segments, all except, usually, a few long basal segments capable of division and reproduction, attached by more or less branched, shorter or longer rhizoids, often coalescing, always attached at first, later sometimes loosening and continuing in a free state; membrane of segments thick, firm, usually distinctly lamellate in age; chromatophore a parietal band, more or less perforate (or in age broken into small disks), with numerous pyrenoids; reproduction by 4-ciliated zoospores produced in little changed segments, and by 2-ciliated isogametes; thick-walled akinetes formed from single segments; mostly marine species.

Kuetzing, Phyc. Germ., 1845, p. 203.

The genus *Chaetomorpha* was founded by Kuetzing in 1845 (May), as indicated above, with fifteen species referred to it, all of which still seem to be closely generically related. It preceded by only two months (cf. Harvey, 1858, p. 84) the publication of Hassall's *Aplonema* (1845, p. 213, July). It seems to be generally recognized as a genus and to be retained in spite of the fact that it approaches *Rhizoclonium* on the one side and *Hormiscia* on the other. From *Rhizoclonium* species in typical form it is readily to be distinguished by the lack of branches of any kind, rhizoidal or otherwise. Some species of *Rhizoclonium,* however, lack all branches and consequently resemble closely the unattached and expanded species or forms of *Chaetomorpha.*

The only differences in such cases are the usually more regularly cylindrical segments of the species of *Rhizoclonium* and the fewer nuclei in each segment. Even these fail in some cases. From *Hormiscia, Chaetomorpha* differs essentially in the characters of the zoospores as indicated under the description of that genus.

The genus *Chaetomorpha* is credited with about fifty species, but some of them will probably be found to be invalid. While we are able to enumerate six species as having been found within our territory, we feel certain that careful search will reveal additional species and varieties.

Chaetomorpha consists of attached, erect species and of horizontal, entangled species unattached at maturity. It is possible that some, at least, of the latter are simply states of the former. Such a relationship is supposed to exist between *Chaetomorpha aerea* (Dillw.) Kuetz. and *C. Linum* (Fl. Dan.) Kuetz. on the one hand, and *C. melagonium* (Web. and Mohr) Kuetz. and the prostrate plant which has been known as *C. Picquotiana* Mont. on the other. This relationship, however, has not been demonstrated by cultures but is inferred from resemblances existing between the supposedly related states or species.

The attached species of *Chaetomorpha* possess an elongated basal segment which produces branched rhizoidal or even rhizome-like processes of attachment from its lower end. These elongated basal segments and organs of attachments distinguish these species of *Chaetomorpha* from those of both *Rhizoclonium* and *Hormiscia.*

The development of the prostrate species of *Chaetomorpha* has not been thoroughly worked out, but judging from what Okamura (1912, p. 163) has found in *Chaetomorpha spiralis* and from what we have observed in *C. torta,* the plants of these species are attached at first, but probably never assume the erect and tufted habit of the other group, very early assuming a prostrate and flexuous or crisped habit, intertwining and becoming detached. It may be that they are states of other species, but it also may be that they are distinct species or, at least, varieties of the erect species they most naturally resemble. Until more is certain along this line, it seems best to keep them distinct and this policy will be followed by us.

Key to the Species

1. Filaments erect, solitary or tufted 2
1. Filaments soon declined, becoming horizontal and entangled 5
   2. Filaments reaching a diameter of 300μ or more 4
   2. Filaments 300μ or less in diameter 3

3. Filaments not over 40μ in diameter.....1. **C. californica** (p. 200)
3. Filaments over 40μ in diameter.....2. **C. aerea** (p. 200)
4. Basal cell short, not over 3 mm. long..... 3. **C. melagonium** (p. 201)
4. Basal cell longer, up to 9 mm. long.....4. **C. antennina** (p. 203)
5. Filaments 45–150μ (or even 200μ) in diameter.....5. **C. cannabina** (p. 204)
5. Filaments over 500μ in maximum diameter.....6. **C. torta** (p. 205)

1. **Chaetomorpha californica** Collins

Filaments attached by a small disk formed of short, stout, coalescent rhizoids, erect, straight or flexuous, of uniform diameter throughout, not contracted at the nodes, about 20 cm. long, 20–40μ diam.; segments 1–2 times, rarely 3–4 times, as long as the diameter.

Growing on sandstone in shallow pools along high-tide level. Observed at Laguna Beach and at La Jolla, southern California.

Collins, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), 1900, no. 664; New species, etc., Rhodora, vol. 8, 1906, p. 106, Green Alg. N. A., 1909, p. 325.

Collins (1909, p. 326) says of this species that it is "the most slender erect marine species known" and that it is "not likely to be mistaken for any other." He has, however, recently described a still more slender species (*C. minima*) from Bermuda. In habit and habitat, *C. californica* resembles *Chaetomorpha aerea* as generally understood, but is much more slender than that species. The basal segment is very suddenly narrowed at the base and is up to 200μ long. The base, itself, is provided with a number of thick, short, very slightly if at all branched, stout rhizoids whose outer walls coalesce to form a sort of disk.

2. **Chaetomorpha aerea** (Dillw.) Kuetz.

Plate 14, figs. 9–11

Filaments rigid, erect, dark green becoming yellowish with age, nearly cylindrical throughout except at the tapering base, attached by delicate rhizoids issuing from the lower end of the basal segment and later coalescent into a more or less solid disk, 125–300μ diam.; segments at first cylindrical, later varying to almost spherical in the fertile segments, 0.5–2 times as long, basal segments much longer; membrane hyaline, thick, at times lamellate; chromatophore at first continuous, finely fenestrate.

Growing in rock pools along high-tide limit or even above. Common on the coast of California from Monterey to San Diego.

Kuetzing, Sp. Alg., 1849, p. 379; Collins, Green Alg. N. A., 1909, p. 324; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 76. *Conferva aerea* Dillwyn, Brit. Conf., 1809, pl. 80.

We feel reasonably safe in referring certain specimens from the central and southern coasts of California to this widespread species after carefully comparing them with specimens from the European and New England coasts. Our plants favor shallow rock pools, more or less lined with sand and situated high up in the littoral belt where the water is warmed by the sun. The specimens available for examination are rather young and range from 200μ to 300μ above. The filaments are erect and tufted, and collapse on being taken from the water. The plants are grass green below but lighter and yellowish above, the color dying away at the tips. This species does not seem to form entangled masses above and we have found no specimens corresponding to the *Chaetomorpha Linum* of the New England coasts and those of Europe, which is supposed to be a state or variety of *C. aerea.* We do not find plants over 300μ in diameter in any of our specimens, whether in those from our own coasts or those from New England or Europe. This is less than the extreme measurements given by some writers (e.g., 600–700μ for zoosporangia by De-Toni, 1889, p. 273) but agrees well with those given by Farlow (1881, p. 46) for the New England plant. The basal segment is short, never ranging, in specimens examined, over 1.5 mm. in length. The upper segments in specimens approaching maturity are short, usually from 0.5 to once as long as broad, but the lower segments may be as much as twice longer than broad. The segments in fertile condition, or approaching it, are slightly swollen and short barrel-shaped.

3. **Chaetomorpha melagonium** (Web. and Mohr) Kuetz.

Filaments closely cespitose or, at times, scattered, attached by short, stout rhizoids coalescing with those of adjacent plants, erect, coarse, stiff, dark glaucous green, 2–6 dm. long, 300–700μ diam.; segments 1–2 diameters long, basal segments slightly attenuated below, up to 2.5–2.75 mm. long.

Unalaska and Kadiak Island, Alaska.

Kuetzing, Phyc. Germ., 1845, p. 204; Collins, Green Alg. N. A., 1909, p. 323; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 222. *Conferva melagonium* Web. and Mohr, Reise nach Schweden, 1804, p. 194, pl. 3, f. 2; Harvey, Phyc. Brit., 1846, vol. 1, pl. 99; Ruprecht, Tange, 1851, p. 396.

Comparatively little is known as to the occurrence of *Chaetomorpha melagonium* on the Pacific coast of North America. Ruprecht (1851, p. 397) credits *Conferva melagonium* to Unalaska and Kadiak Island in tufts over two feet long. Kjellman (1889, p. 55) credits it in typical form to St. Lawrence Island and to Port Clarence. Setchell (1899, p. 590) refers some fragments from the Pribilof Islands to the typical form and Sounders (1901, p. 413) credits Yakutat Bay, Alaska, with the f. *rupincola* (Aresch.) Kjellm. Kjellman unites *Chaetomorpha melagonium* (Web. and Mohr) Kuetz. and *C. Picquotiana* Mont. under *Chaetomorpha melagonium* f. *typica*. The type of *C. melagonium* is evidently a tall, rigid, erect, and attached plant and, judging from the description, so is *C. Picquotiana*. Whether or not the coarse, horizontal, and entangled plant of New England (cf. Farlow, 1881, p. 47) which has gone under the latter name is the true *C. Picquotiana* and whether or not it is also a state of *C. melagonium* are questions which we cannot decide at present; nothing like it, however, has been definitely recorded for our Alaskan waters.

Collins, 1909 (p. 324) states that *Chaetomorpha melagonium* f. *typica* Kjellm. is the unattached plant forming crisped and entangled masses about the roots of *Laminariae* in the sublittoral belt. We do not find that Kjellman so describes it anywhere, but he does distinctly cite the reference of Weber and Mohr, who describe and figure their *Conferva melagonium* as erect, attached, and tufted. The original description of *Conferva Picquotiana* Mont. (1849, p. 66) says "rigida, erecta" and below also "basi adnata," so that it does not seem as if either *Chaetomorpha melagonium* or *C. Picquotiana*, whether the two may be distinct or identical, is unattached and horizontal in characteristic form.

As to f. *typica* Kjellm. (1883, p. 312) and f. *rupincola* Aresch. (Alg. Scand. Exsicc., no. 275 a) the essential differences seem to be that the former has longer segments and the latter shorter segments. The prostrate plant of the New England coast has longer segments and, if it is to be regarded as a state of *C. melagonium*, ought, therefore, to be placed under f. *typica*.

Under *Chaetomorpha melagonium* may be mentioned the *Conferva confervicola* Ruprecht (1851, p. 397) reported as having been found epiphytic on, and attached basally to, *Chaetomorpha melagonium* at Sitka, Alaska. Harvey (1858, p. 88) states that he received a specimen of this plant from Ruprecht and suggests that it may be the young and attached state of *Chaetomorpha tortuosa*. It may possibly be the young attached state of what we have called *Chaetomorpha cannabina*.

4. **Chaetomorpha antennina** (Bory) Kuetz.

Filaments dark green, tufted, 4–9 cm. long, erect, rigid below, somewhat less so above, more or less clavate; basal segments 5–9 mm. long, emitting long, slender, intertwined, branching rhizoids from its base; segments 450–900μ in diameter, 1–4 times as long as broad, fertile somewhat swollen, walls finally thickened (up to 25μ thick) and stratified.

St. Augustin and Mazatlan, Mexico.

Kuetzing, Sp. Alg., 1849, p. 379; Collins, Green Alg. N. A., 1909, p. 324, Suppl. II, 1918, p. 79; Howe, Mar. Alg. Peru, 1914, p. 37. *Conferva antennina* Bory, Voy. quatre îles d'Afr., vol. 2, 1804, p. 161, Voy. Coquille, 1828, p. 227; Montagne, Voy. au Pol Sud, 1845, p. 4. *Chaetomorpha pacifica* Kuetzing, Sp. Alg., 1849, p. 379.

There are two coarse, rigid species of *Chaetomorpha* on the Pacific Coast of North America, viz., *C. melagonium* and *C. antennina*. The first is Alaskan, inhabiting the cold waters of the Boreal zones, while the second is found in tropical waters on the coast of Mexico. *C. melagonium* is a species reaching a length of several dm. while *C. antennina* is seldom over 1 dm. The basal segment in *C. melagonium* is short, not over 3 mm., while that of *C. antennina* is long, reaching a length of 5 to 9 mm.

Howe (*loc. cit.*) has examined the type of *Chaetomorpha antennina* (Bory) Kuetz. and also the Mexican type of *C. pacifica* Kuetz. He judges them to belong to the same species as does also the *Chaetomorphopsis pacifica* Lyon (*in* Tilden, Amer. Alg., Cent., 5, 1901, no. 458). He has also examined the Mazatlan plants collected by Dr. and Mrs. Marchant and, although there are some differences in diameters and length of basal segments, expresses his opinion that they, also, are best placed under *C. antennina*.

The type locality of *Chaetomorpha antennina* is Reunion or Bourbon Island. The specimens upon which *C. pacifica* is based come from Java and from St. Augustin, Mexico. Lyon's *Chaetomorphopsis pacifica* came from the Hawaiian Islands. *Chaetomorpha antennina*, then, in this interpretation is a widespread Indo-Pacific species, ranging from the tropical shores of Pacific North America to those of eastern Africa. The West Indian specimens formerly referred to *C. antennina* seem better referred to *C. media* (Ag.) Kuetz. (cf. Howe, 1914, p. 37).

5. **Chaetomorpha cannabina** (Aresch.) Kjellm.

Filaments unattached, except possibly in the early stage, entangled, soft and rather delicate, color light green, 45–150μ diam., narrow and wide together in the same mass, or even a single filament tapering from larger to smaller measurement; segments 3–8 diameters long, uniformly 500–600μ long.

Growing in tangled masses among other algae, and on wood between tides. From Alaska to Puget Sound, Washington.

Kjellman, Om Beringh. Algfl., 1889, p. 55; Collins, Green Alg. N. A., 1909, p. 325; Saunders, Alg. Harriman Exp., 1901, p. 413; Setchell and Gardner, Alg. N.W., Amer., 1903, p. 221; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 916. *Conferva cannabina* Areschoug, Alg. Sc. Ex., ed. 1, no. 14, 1840, ed. 2, no. 135, Alg. minus rite cog., Pug. II, 1843, p. 268, pl. 9, Phyc. Scand., 1850, p. 433.

What passes for *Chaetomorpha cannabina* seems to be fairly frequent along our coast from Puget Sound northward to Bering Sea. The habit is that of entangled prostrate masses, free or intertwined with other algae. No organs of attachment have been found in any of the specimens. The filaments are long, crisped and often intricately entangled. The diameters of the segments range from 44μ to 125μ in our specimens and a considerable range of variation is usually found in the same mass and even in the same filament.

In attempting to determine the exact status of the *Conferva cannabina* Areschoug, we are met at once with conflicting statements in the various descriptions of Areschoug. In 1843 Areschoug described the species as having filaments $\frac{1}{32}$–$\frac{1}{25}$ linc in diameter which, assuming this to be the "Paris" line, means from 73μ to 90μ. In 1850 Areschoug, however, states that the more slender filaments are 0.10 mm. and the thickest are 0.20 mm., thus indicating 100μ to 200μ for the diameter of the filaments. An examination of no. 135 of the second issue of the Algae Scandinavicae Exsiccatae shows filaments ranging from 85μ to 145μ.

Our west American specimens agree fairly well with the specimens distributed by Areschoug under no. 135 of the second issue of his Algae Scandinavicae Exsiccatae (the first issue is not accessible to us) and it seems best to retain his name for our species, at least for the present. It seems also, judging from the specimen in the Herbarium of the Imperial Academy at St. Petersburg, to be the plant described as *Conferva tortuosa* var. *crassior* by Ruprecht (1851, p. 399) which

was collected at Sitka, Alaska. Harvey (1858, p. 87) referred Ruprecht's plant to his *Chaetomorpha litorea* (cf. Harvey, 1849, p. 208 and 1851, pl. 333, under *Conferva*). The *Chaetomorpha litorea* Harv. itself, judging from descriptions and figures, is closely related to *C. cannabina* if not identical with it.

The *Chaetomorpha confervicola* (Rupr.) De-Toni (1889, p. 268) is a slender attached species growing on *C. melagonium* at Sitka (cf. Ruprecht, 1851, p. 397). This is suggested as being the young attached state of *Chaetomorpha tortuosa* (*Rhizoclonium tortuosum* of this account), but it seems fully as probable that it may be the young and attached state of *C. cannabina*.

6. **Chaetomorpha torta** (Farlow) McClatchie

Filaments rigid, attached when young, soon becoming declined, loosened and entangled among other algae, much coiled and contorted, 40–60 cm. long, up to 1 mm. in diam., nearly uniform throughout with segments slightly moniliform, 1–1.5 times as long as broad; color iridescent bluish green.

Growing in the sublittoral belt. Southern California.

McClatchie, Seedless plants, 1897, p. 351 (nomen nudum); *in* Yendo, Notes on algae new to Japan II, 1914, p. 264 (excl. syn. *C. spiralis*). · *Chaetomorpha clavata* var. *torta* Farlow, *in* Farlow, Anderson and Eaton, Alg. Exsicc. Amer.-Bor., fasc. 5, 1889, no. 211 (nomen nudum); Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), fasc. XII, 1899, no. 571 (nomen nudum); Farlow, *in* Collins, Green Alg. N. A., 1909, p. 323 (descr.). *Chaetomorpha clavata* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 371 (not of Kuetzing).

Chaetomorpha torta is confined, so far as our knowledge goes, to the coast of southern California. It is so different from any of our other species as to be readily recognizable by its scattered or massed, long, coarse, contorted and even spirally coiled, rigid filaments of a peculiar light bluish green color. In searching for any trace of an attachment, our persistence was rewarded by the discovery of one among all the material examined and that, curiously enough, was found on no. 211, of Farlow, Anderson and Eaton's Algae Americae Borealis Exsiccatae. The rhizoids are slender, blunt, somewhat branched, and evidently were attached to a rock surface. The basal segment is slightly attenuated below and about 2 mm. long. The

filament was bent over and declined just above the basal segment. The method of attachment and later growth of *Chactomorpha torta* and *C. spiralis* Okam. seem to indicate the possibility of the prostrate species of *Chactomorpha* being not later stages in growth of the erect species, but distinct species, declined almost from the first and resembling the species of *Rhizoclonium* in this respect as has been suggested above.

The status of the name is somewhat complicated. It was first published by Farlow in the form "*Chaetomorpha clavata* var. *torta* Farlow," in connection with a distributed specimen and printed label but without description. The description was appended first by Collins in 1909. The combination "*Chaetomorpha torta* Farlow" was first used in 1897 by McClatchie, but without description or citation. Yendo (1914, p. 264) used the combination "*Chaetomorpha torta* McClatchie," citing the various references to the California plant and assigning also as a synonym, the *Chaetomorpha spiralis* Okamura (1912, p. 95). Collins (1918, p. 78) has finally reviewed the situation and argued for the etiquette "*Chaetomorpha torta* (Farlow) Yendo." It seems to us, while agreeing in general with the principles enunciated by Collins in his later paper, better to write "*Chaetomorpha torta* (Farlow) McClatchie" *in* Yendo, Notes on algae new to Japan, etc. Otherwise, and following out literally the contention of Collins, it should be written "*Chaetomorpha torta* (Collins) Yendo," since Collins was the first to make the varietal name valid. It must be borne in mind, however, that the situation is further complicated by the fact that the varietal name had not been validated when McClatchie published his combination.

Chaetomorpha torta has been associated with *C. clavata* (Ag.) Kuetz. and with *C. spiralis* Okam. The former is a plant described from the West Indies and has erect, straight filaments, tapering from below upward. *C. spiralis*, on the other hand, although attached at first, is soon declined, flexuous, and spirally twisted, with segments much narrowed towards the base, short and much swollen above and reaching a maximum diameter of 2.5 mm. In all these characters, *C. spiralis* differs from *C. torta* and should be kept distinct. From *Chaetomorpha moniligera* Kjellman (1897, p. 24, pl. 4, f. 17–23), an erect and delicate, though broad, species, both *C. spiralis* and *C. torta* seem amply distinct.

13. **Cladophora** Kuetz.

Plants composed of filaments of a single series of segments, the filaments branching, usually abundantly; branching lateral, but often coming to appear dichotomous in consequence of the pushing aside of the original filament by the branch; growth in length chiefly by division of the apical segment, subsequent division of segments being rather exceptional; branches all of the same type but different orders usually differing in diameter; segments multinucleate, the chromatophore either covering the segment wall, or forming a network on it, or in the form of numerous small disks; pyrenoids several in a segment; reproduction by 4-ciliated zoospores, and by 2-ciliated gametes, uniting and germinating immediately, or sometimes germinating without copulation.

Kuetzing, Phyc. Gen., 1843, p. 262.

The genus *Cladophora* was established by Kuetzing in 1843, the same year that Hassall (1843, p. 363, May) proposed the genus *Microspora* to include the branching species of the old genus *Conferva*. It is possible that *Microspora* Hassall antidates *Cladophora* Kuetzing, but Hassall (1845, p. 213) withdrew his genus and adopted that of Kuetzing. The name *Microspora* was later used by Thuret (1850, p. 221) to designate a later segregation from *Conferva* and this name is still current in the sense indicated by Thuret.

The type species of Kuetzing's genus is the *Conferva oligoclona* Kuetzing (1833, no. 62), a fresh-water species and there is little question as to the limits of the genus, except possibly towards some of its segregates. It is distinctly and readily separated from *Chaetomorpha* by its branching and from *Rhizoclonium* by the method of its branching. The difficulties of separating *Spongomorpha* Kuetz., *Aegagropila* Kuetz. and *Acrosiphonia* J. Ag., if it seems best to do so, are at times considerable. The species of all these genera are of more spongy habit than are those of the true or typical *Cladophora*. In *Spongomorpha* and *Acrosiphonia* the spongy condition is brought about by specialized rhizoidal or spinelike branches which hold the mass of branches together. In *Aegagropila*, there are no such specialized branches and it has seemed best to us not to separate the species of *Aegagropila* from those of *Cladophora*. The distinction between the two genera depends largely upon habit and is not always applicable with certainty and precision.

The determination of species of *Cladophora* presents unusual difficulties. The synonymy, especially of older specific names, is very much unsettled and intertangled. The identity between species of different coasts and oceans is very uncertain, and the recognition of species in their various ages and under varying conditions seemingly most difficult. We have adapted our account very largely from Collins (1909) and have accepted his determinations and limitations of species, since we ourselves have very little opportunity for the study of this genus and possess few facilities for the proper comparison of our west coast plants with authentically determined specimens from other coasts. It is desirable that collectors pay careful attention to these plants, to their seasonal conditions, their fertile states, their earlier stages of growth as well as adult, and attempt to make better known the entire life-history of our various species and forms.

Key to the Species

1. Low, pulvinate or matted, creeping at the base 2
1. Erect, tufted or loosely spreading 4
    2. Branching irregular, not at all dichotomous ..... 1. **C. amphibia** (p. 209)
    2. Branching dichotomous or trichotomous, except above 3
3. Main filaments 60–150μ in diameter ..... 2. **C. hemisphaerica** (p. 209)
3. Main filaments 120–250μ in diameter ..... 3. **C. trichotoma** (p. 210)
    4. Main filaments usually over 150μ in diameter 5
    4. Main filaments usually under 150μ in diameter 9
5. Lower segments 10 or more diameters long ..... 4. **C. graminea** (p. 211)
5. Lower segments less than 10 diameters long 6
    6. Ramuli curved ..... 5. **C. microcladioides** (p. 212)
    6. Ramuli straight 7
7. Ramuli only slightly less stout than branches ..... 6. **C. Hutchinsiae** (p. 213)
7. Ramuli very much less stout than branches 8
    8. Main filaments 112–200μ in diameter ..... 7. **C. ovoidea** (p. 214)
    8. Main filaments 135–300μ in diameter ..... 8. **C. MacDougalii** (p. 214)
9. Main filaments distinctly zig-zag or flexuous 10
9. Main filaments straight or nearly so 13
    10. Ramuli clustered at the tips ..... 9. **C. laetevirens** (p. 216)
    10. Ramuli not clustered at the tips 11
11. Main filaments coarse, up to 150 (or 160) μ ..... 10. **C. gracilis** (p. 216)
11. Main filaments slender, not over 80μ 12
    12. Segments long below (up to 6 diam.), shorter (as low as 2 diam.) above ..... 11. **C. flexuosa** (p. 217)
    12. Segments long throughout ..... 12. **C. Rudolphiana** (p. 217)
13. Ramuli curved ..... 13. **C. Bertolonii var. hamosa** (p. 218)
13. Ramuli straight 14
    14. Main filaments not over 30μ in diameter ..... 14. **C. albida** (p. 218)
    14. Main filaments considerably over 30μ in diameter 15
15. Ramuli acute ..... 15. **C. glaucescens** (p. 219)
15. Ramuli blunt 16
    16. Branching dichotomous below the tips ..... 16. **C. Stimpsonii** (p. 219)
    16. Branching nowhere dichotomous ..... 17. **C. delicatula** (p. 220)

1. **Cladophora amphibia** Collins

Basal layer of densely branching, prostrate filaments, segments cylindrical, 40–70μ diam. and 2–5 diam. long, or fusiform, 1–2 diam. long, swollen to 100μ in the middle, emitting erect filaments with segments 30–50μ diam., 4–8 diam. long, cylindrical or irregular, terminal segments obtuse or truncate; slender descending rhizoids sometimes issuing from lower segments of erect filaments.

Growing on the ground among *Salicornia* and other salt marsh plants along high-tide line. Known only from a single locality, viz., Alameda, along the shores of San Francisco Bay, California.

Collins, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1284 (nomen nudum), and *in* Rhodora, vol. 9, 1907, p. 200 (description), Green Alg. N. A., 1909, p. 349.

Collins has correctly described this species as a "dull green unattractive plant." It is not readily mistaken for any other, both as regards its habitat and its habit. It is low and forms extended patches along the salt marsh covering of *Salicornia*. Its discovery in similar localities along the coast is to be expected. The species would ordinarily be grouped with those of the *Aegagropila* section; it is matted together below by the intertwining of the prostrate filaments and by the descending slender almost rhizoidal branchlets. The branching is irregularly alternate and not at all dichotomous. The turflike layer is not over a centimeter in thickness.

2. **Cladophora hemisphaerica** Gardner

Plants at first compact, hemispherical, of not over 1 cm. radius, profusely branching at the base, dichotomous, forkings narrow, segments 60–150μ diam., 3–6 diam. long, often distinctly clavate; later less regularly hemispherical, up to 3 cm. or more radius, branches more distant, with segments in the upper part 50–80μ diam., cylindrical; numerous slender tufts, up to 1 dm. long, on nearing maturity arise from the hemispherical mass, having cylindrical segments 50–80μ diam., with forkings very distant and narrow; substance firm, not adhering well to paper.

Growing in small, shallow pools on rocks in the upper littoral belt. Cypress Point, Monterey County, California.

Gardner, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2240 (nomen nudum), *in* Collins, Green Alg. Suppl. II, 1918, p. 83 (descr.).

Cladophora hemisphaerica is another species of the *Aegagropila* section, found thus far in a single locality, but growing on rocks where the small indentations retain water at the upper limits of the littoral belt. The filaments are bound together at the base by descending rooting branchlets but are entangled above. Tufts growing in deeper pools sometimes give rise to more slender and looser erect tufts more like individual plants of the *Eucladophora* section.

Cladophora hemisphaerica resembles somewhat *C. trichotoma*, as found on our coasts, but is more distinctly tufted, of different aspect and with more slender filaments. It is attached very firmly to the wave-swept rocks.

3. **Cladophora trichotoma** (Ag.) Kuetz.

Plate 16, fig. 2

Plants forming light or bright green, densely pulvinate masses, 2–5 cm. high in shallow pools, and up to 2.5 dm. in deep, quiet pools; filaments procumbent at the base, stiff, di-trichotomous, with rather few, short, alternate, rarely opposite branches, fastigiate at the tips; segments 120–250μ diam., 4–10 diam. long, nearly cylindrical below, above ovoid to pyriform; the branches about the same diameter as the filament.

Growing in rock pools near high water mark. Vancouver Island, British Columbia, to La Paz, Lower California.

Kuetzing, Sp. Alg., 1849, p. 414; Collins, Green Alg. N. A., 1909, p. 349; Howe, Phyc. Studies V, 1911, p. 492; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 820. *Conferva trichotoma* Agardh, Syst., 1824, p. 121. *Cladophora repens* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 727 (not of Harvey). *Cladophora columbiana* Collins, *in* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 226. *Cladophora composita* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 226, as to "N. L. G. no. 521." *Cladophora cartilaginea* Tilden, Amer. Alg. (Exsicc.), no. 376.

Cladophora trichotoma is the most common of all our species of *Cladophora* and is usually abundant on all rocky shores from Vancouver Island to La Paz in Lower California. It grows high up on the bare rocks or in small pools where its compact bright green cushions or expanded tufts form conspicuous objects. Our plant has been compared with a fragment of the type specimens and agrees so closely as to be referred here with considerable confidence. Its exten-

sive distribution is to be explained, in all probability, by its occurrence so high up in the littoral belt that it is enabled to receive much heat from the sun and the air, while its dense tufts allow it to remain exposed at low tide without drying.

Cladophora trichotoma f. **elongata** Collins

A luxuriant form, sometimes up to 3 dm. high; fronds sparingly branched except near the surface of the water, where it forms characteristic dense tufts.

Growing on the margins of deep rock pools little affected by tides. Point Carmel, "Point Lobos," Monterey County, California.

Collins, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2141, Green Alg. Suppl. II., 1918, p. 81.

The typical form of *Cladophora trichotoma* is truly a member of the *Aegagropila* section of the genus *Cladophora* and occurs in dense cushions or tufts, low and spreading by prostrate branches which descend, attach themselves, and send off erect branches in turn. When growing in deep rock pools, and, therefore constantly immersed, the low cushions give off erect and luxuriant tufts of filaments, loosely entangled and sparing branched, until they reach the surface. These erect tufts simulate the plants of the *Eucladophora* section, and may pass for them unless care is taken to study the base. We feel fairly certain in referring here no. 127, Butler and Polley, collected at Port Renfrew, British Columbia and listed in Setchell and Gardner, Algae of Northwestern America (1903, p. 228) as *Cladophora Hutchinsiae* var. *distans*.

4. **Cladophora graminea** Collins

Plants loosely tufted, 10–15, cm. high, dark green, cartilagineous, very rigid, distantly di-trichotomous, all divisions erect; main filaments about 300μ diam., ultimate divisions about 150μ diam., tips blunt or slightly acute; segments very long below, up to 30 diam., shorter above, normally occupying the space from one forking to another; ultimate branches 4–6 diam. long; segment walls usually strongly lamellate.

Growing in rock pools usually in shaded habitats, in the upper littoral belt. Known along the California coast from Monterey to San Diego.

Collins, *in* Rhodora, vol. 11, 1909*a*, p. 19, pl. 78, f. 6. *Cladophora erecta* Collins, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1690.

Cladophora graminea is one of the coarsest of our west coast species of erect *Cladophoras,* superficially resembling a species of *Spongomorpha* in this and in its habit. It has been usually confused with *C. cartilaginea* which, properly, is a *Spongomorpha.* In its regular or unequal, dichotomous branching, where each arm is composed of a single segment, in its coarseness, as well as in the proportional length of the segments, it is to be distinguished from all our other species.

5. **Cladophora microcladioides** Collins

Plate 13, fig. 2

Plants more or less densely tufted, 10–20 cm. high; filaments about 200μ diam. at the base, segments 4–6 diam. long; stiff, straight or flexuous, distantly di-trichotomous, branches similar, erect or more or less recurved, bearing on the upper (inner) side numerous short branches, rarely with very short branches opposite one or more of them; this ramification continued, the ultimate ramuli of very few segments, 80–100μ diam., segments 1.5–2.5 diam. long.

Growing in the upper sublittoral belt. From Vancouver Island, British Columbia, to San Diego, California.

Collins, *in* Rhodora, vol. 11, 1909a, p. 17, pl. 78, f. 2, 3, Mar. Alg. Vancouver Island, 1913, p. 104.

Cladophora microcladioides f. **stricta** Collins

Similar to the species but differing in habit; branches of various orders virgate and little recurved.

Lower littoral belt. San Diego, California.

Collins, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1583.

In its typical form *Cladophora microcladioides* is one of our most readily recognized species of the *Eucladophora* section or erect *Cladophoras.* The regular recurved branches give the plant much of the habit of *Microcladia borcalis* Ruprecht. There is much variation in height, flexuosity of principal axes, frequency of recurved pinnules, etc., but the pinnules are distinctive and usually readily recognizable. In the forma *stricta,* however, the pinnules are not recurved, but there is more or less of an indication of the close affinity with the species.

6. **Cladophora Hutchinsiae** (Dillw.) Kuetz.

Plants glaucous green, up to 40 cm. high; filaments 120–300μ diam., stiff, flexuous, sparingly branched; ramuli few, secund, blunt, with constricted nodes; cells 2–3 diam. long.

Vancouver Island, British Columbia.

Kuetzing, Phyc. Germ., 1845, p. 210; Collins, Green Alg. N. A., 1909, p. 345. *Conferva Hutchinsiae* Dillwyn, Brit. Conf., 1809, pl. 109.

Cladophora Hutchinsiae var. **distans** (Ag.) Kuetz.

Segments of primary branches longer than in the type, 280–400μ diam., with few secondary branches whose segments are 200–250μ diam., 3–4 times as long as the diameter.

West coast of Vancouver Island, British Columbia.

Kuetzing, Sp. Alg., 1849, p. 392; Collins, *loc. cit.;* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 228. *Conferva distans* Agardh, Syst., 1824, p. 120.

Cladophora Hutchinsiae is one of the coarser species of the *Eucladophora* section, whose branchlets are only slightly reduced in diameter from the branches from which they spring. We have seen no specimens from our coast and Collins (1909, p. 345) gives only "Vancouver Island," stating (*loc. cit.*, p. 346) that it is likely to be found "on the west coast south of Vancouver." In his Marine Algae of Vancouver Island, however, Collins (1913, p. 104) lists only the var. *distans* as occurring at Port Renfrew, where it was collected by Butler and Polley. No. 127 of their collection, as distributed, which is the plant in question, seems clearly to be *Cladophora trichotoma* f. *elongata* Collins. In his Marine *Cladophoras* of New England, Collins says (1902, p. 126) that the type of *C. Hutchinsiae* has never been certainly known from New England, the one quoted by Farlow in the Marine Algae of New England proving to be wrongly marked and to belong to California. The status of the species on the West Coast, therefore, is not exactly established.

Cladophora Hutchinsiae is to be distinguished from both *C. ovoidea* and *C. MacDougalii* by the stout branchlets, the ultimate ramuli being, for the most part, of only one or two segments.

There is doubt, at least, as to the reference of var. *distans* to our coast, the Butler and Polley specimen (no. 127) seeming to be erron-

eously determined, as stated above. We are, however, inclined to refer here a specimen collected by one of us (Gardner, no. 4104) at Lands End, San Francisco, California. The specimens seem to agree well with Harvey's figure of *Cladophora diffusa* (1849, pl. 130) and fairly well with the figure of Dillwyn's *Conferva diffusa* (1803, pl. 21), and possibly also with the plate of Roth (1800, pl. 7). The San Francisco plant is more slender than the type of the species, with less profusion of branches and branchlets, and, in this, agrees with Harvey's *C. diffusa*. The synonymy, however, is too confused to be unraveled, at least at present.

7. **Cladophora ovoidea** Kuetz.

Plants 5–15 cm. high, stiff, rather dull green; filaments distantly dichotomous, 150–200μ diam. below, branches becoming more lateral and secund above; upper ramuli not over 60μ diam., tips rounded or slightly pointed; segments in lower part cylindrical, 4–8 diam. long; above ovoid, 1.5–3 diam. long.

Known only from Carmel Bay and Santa Cruz in California.

Kuetzing, Phyc. Gen., 1843, p. 266, Tab. Phyc. III, 1853, pl. 92, f. 1; Collins, Green Alg. N. A., 1909, p. 346.

We have seen only specimens identified by Collins and have been unable to compare them with European plants of *Cladophora ovoidea*. Our specimens are coarse, of the same general appearance as those of *C. Hutchinsiae*. The branchlets, however, are much more slender than the branches from which they spring and are, for the most part, composed of four to six segments. The upper segments are more or less ovoid. Our plants resemble reasonably closely the figures of Kuetzing (1853, pl. 92, f. 1).

8. **Cladophora MacDougalii** Howe

Plants rather stout, coarse and rigid, in strict tufts, dark or yellowish green, 10–17 cm. high; main filaments 135–310μ diam., sparingly dichotomous below the middle of the tufts; branching in median and upper parts lateral, the branches erecto-patent, secund, occasionally alternate, or very rarely opposite, becoming more or less secund-pectinate toward the apices, the main axes commonly excurrent beyond the last lateral branch as rather rigid tapering prolongations 10–40 segments long; the ultimate lateral branchlets 75–110μ diam.,

about one half the diameter of the filaments from which they spring, usually 3–7 segments long, in most cases gradually tapering from near the base, subacute or blunt, commonly rather rigid; segments in extreme basal parts 6–15 times as long as broad, in median and upper parts 1–4 (mostly 1.5–2.5) times as long as broad, usually a little constricted at the septa and appearing quite strongly constricted when dry.

San Felipe Bay, Lower California.

Howe, Phyc. Studies V, 1911, p. 491, pl. 33, f. 7.

Collins (Green Alg. Suppl. I, 1912, p. 96) appends the following note to *C. ovoidea,* "This species," referring to *C. MacDougalii,* "is compared by its author with *C. Hutchinsiae* (Dillw.) Kütz., and *C. Ovoidea* Kütz., but is considered distinct from both. A specimen kindly furnished by the author shows that it is amply distinct from the *C. Hutchinsiae* of England and France, N. J. and Barbados. It is, however, quite close to the California plant given as *C. ovoidea* by the writer, 1909, p. 346, and would have been placed there without question. It may well be that it is distinct from the *C. ovoidea* of Europe, which appears to be a little known species. The California plant is larger in all dimensions, less moniliform, and with long excurrent axes. A comparison of specimens from various stations shows much variation in the two last particulars, but all are much stouter than *C. ovoidea* as originally described. It often varies in the direction of *C. microcladioides* Collins, with denser and more fasciculate branching."

Howe says (1911, p. 492): "We have seen no European specimens of *C. ovoidea,* but are unwilling at the present time to identify with this species a Lower California plant with filaments and branches averaging twice as thick as those of the plant described and figured by Kützing, and with filaments so little constricted at the septa (in a soaked out condition, at least) that no one would think of describing any of the cells as 'ovoid' (Kützing, Phyc. Gen., 266). Also, according to Kützing's figure (Tab. Phyc., 3:26, pl. 92, f. 1, 1853), the branching in *C. ovoidea* is more fasciculate than in *C. MacDougalii,* the ultimate lateral branchlets are less tapering and less rigid, and the main axes do not show the long-excurrent prolongations of the Baja California species."

It seems best to us to retain *C. MacDougalii* as a distinct species.

9. **Cladophora laetevirens** (Dillw.) Kuetz.

Plants 15–20 cm. high, erect, rigid, bright yellow green; filaments much branched, flexuous, 50–150μ diam.; branches erect, often opposite; ultimate ramuli short (usually 1–3 segments), obtuse or subacute, densely fastigiate at the tips of the branches; segments of main branches 6 diameters long, of ramuli 3 diameters.

Kuetzing, Phyc. Gen., 1843, p. 263; Harvey, Phyc. Brit., vol. 2, 1849, pl. 190; Notice of a collection of algae, etc., 1862, p. 177; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 224; Collins, Green Alg. N. A., 1909, p. 345. *Conferva laetevirens,* Dillwyn, Brit. Conf., 1805, pl. 48.

The only reason for including this species beyond the record of Harvey (1862*a*, p. 177) for Fuca Strait, apparently based on two small and young specimens, is the collection of what seem to be characteristic specimens by Butler and Polley near Port Renfrew, B. C. These have been carefully compared with no. 143 of Wyatt's Algae Danmonienses both by F. S. Collins and by ourselves and they seem to be in close agreement with it.

10. **Cladophora gracilis** (Griff.) Kuetz.

Plants moderately rigid, forming somewhat slender, pyramidal fascicles, 15–30 cm. high, pale or glaucous green, di- trichotomous at the base; main filaments up to 160μ diam., segments 4–7 times as long as the diameter; main branches smaller and beset with numerous slender, tapering, secund ramuli constricted at the joints.

Growing on rocks in shallow tide pools, in the upper and middle littoral belts. Sitka, Alaska, and Neah Bay, near Cape Flattery, Washington.

Kuetzing, Phyc. Germ., 1845, p. 215; Collins, Green Alg. N. A., 1909, p. 342. *Cladophora vadorum* Kuetzing, Sp. Alg., 1849, p. 402, Tab. Phyc., vol. 4, 1854, p. 4, pl. 20, f. I. *Conferva gracilis* Griffiths, *in* Wyatt, Alg. Danm., no. 97.

The limits of *Cladophora gracilis* have not been clearly defined. Either it is an exceedingly variable species, or several closely related species have been grouped into one by different authors. Kuetzing (1845, p. 215) gives 113–124μ, De-Toni (1889, p. 322) gives 100–140μ, and Collins (1909, p. 342) gives up to 160μ as the diameter of the main filaments of this species. Collins (*loc. cit.*, p. 343) has recognized

five forms of this species as abounding on the Atlantic coast of North America.

We are placing under *C. gracilis* two sets of plants differing considerably from one another, mainly in details of measurements, as apparently closely allied to the Atlantic coast forms, but they do not seem to be identical with any of them. No. 3954 Gardner, from Sitka, Alaska, has the main filaments up to 100μ in diameter. No. 3870*a* Gardner, from Neah Bay, Washington, has slightly smaller dimensions than no. 3954. The ultimate ramuli in both of the above mentioned collections, while being more or less secund, are not so much so as is usually recorded for the species. No. 3870*a* is fruiting abundantly at the tips of the ramuli, the segments becoming decidedly ventricose or even spherical in reproduction. These two collections are placed here provisionally awaiting further investigation into the status of the species.

11. **Cladophora flexuosa** (Griff.) Harv.

Plants 10–20 cm. high, light green; main filaments 80–120μ diam., regularly flexuous, with flexuous alternate branches, 40–80μ diam., which in turn have alternate or secund, curved and sometimes refracted ramuli; segments from 6 diam. long below to 2 in the ramuli.

Growing in rock pools in the lower littoral belt. Annettee Island, Alaska, to San Diego, California.

Harvey, Phyc. Brit., 1851, p. 353; Collins, Green Alg. N. A., 1909, p. 339; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 224; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2239. *Conferva flexuosa* Griffiths, *in* Wyatt, Alg. Danm., no. 227.

The status of the name *Cladophora flexuosa* is equivocal. The plant usually referred here does not seem to be at all certainly the *Conferva flexuosa* Dillwyn (1802, pl. 10) nor that of Mueller in the Flora Danica (1782, p. 5, pl. 882), but more probably that of Mrs. Griffiths (*in* Wyatt's, Alg. Danm., no. 227), later adopted by Harvey (1851, pl. 353) and referred to *Cladophora*. Our west coast plants have been referred here chiefly on the authority of Collins.

12. **Cladophora Rudolphiana** (Ag.) Kuetz.

Plants loose, soft, yellowish green, gelatinous, up to a meter in length; main filaments 40–80μ diam.; branches alternate or opposite, patent, flexuous, ramuli secund, tapering, about 20μ diam.; segments much longer than broad, up to 20 diam. below.

Kuetzing, Phyc. Gen., 1843, p. 268; Harvey, Phyc. Brit., 1846, pl. 86; Collins, Green Alg. N. A., 1909, p. 336.

The typical form has not as yet been detected on our coast. It is to be distinguished by its soft and gelatinous consistency and its segments which are long throughout the plant.

Cladophora Rudolphiana f. **eramosa** Gardner

Branches very long, subsimple.

Growing in a warm salt water pond. Key Route Power House, Oakland, California.

Gardner, *in* Collins, Green Alg. Suppl. II, 1918, p. 81; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2241.

A curious plant, seemingly nearest to *Cladophora Rudolphiana*, has been found in flowing warm salt water. The branching is very slight. The main filaments are 55μ to 60μ diameter and the ramuli about 25μ diameter. The lower segments are from 4.5 to 6.5 diameters long.

13. **Cladophora Bertolonii** var. **hamosa** (Kuetz.) Ardiss.

Plants 3–10 cm. high, dark green; filaments rather stiff, 80–100μ diam. in the main divisions, 25–30μ in the ramuli; much branched, main divisions di- trichotomous, opposite or whorled branches, usually short and with densely set, secund, recurved ramuli, segments 1.3–3 diameters long, rarely more, terminal segments rounded, not tapering.

Central California (Pacific Grove).

Ardissone, Phyc. Med., 1886, part II, p. 242; Collins, Green Alg. N. A., 1909, p. 344. *Cladophora hamosa* Kuetzing, Phyc. Gen., 1843, p. 267, Tab. Phyc., 1854, vol. 4, pl. 8, f. 2.

We know of this plant only from the report of Collins (*loc. cit.*), who appends the following remarks: "The California plant seems to be more slender than the European, seldom exceeding 60μ in the main branches and 25μ in the ramuli. The dark color, short cylindrical cells and elegant feathery tips, with a long series of secund, usually slightly recurved ramuli on the similarly recurved branches, are fairly clear characters."

14. **Cladophora albida** (Huds.) Kuetz.

Plants soft, dense, pale green, filaments 20–30μ diam., segments 4–5 diameters long, delicate; branching irregular, ramuli long, patent, blunt.

Known in our region from East Sound, Washington, and San Pedro, California.

Kuetzing, Phyc. Gen., 1843, p. 267; Collins, Green Alg. N. A., 1909, p. 336. *Conferva albida* Hudson, Fl. Ang., 1762, Ed. I, 1778, Ed. II, p. 595; Dillwyn, Brit. Conf., 1809, p. 32, pl. E.

Cladophora albida is our most slender species as well as one of very soft and spongy consistency. By these characters it is usually to be distinguished, whether living or in dried specimens.

15. **Cladophora glaucescens** (Griff.) Harv.

Plants 10–40 cm. long, glaucous or yellowish green, loosely tufted, much branched, ending in long, erect, acute, alternate or sometimes secund, ramuli; segments at base 50–60μ diam., in ramuli 25–30μ; segments usually 4–6 diam. long, sometimes considerably longer.

Nanaimo, Vancouver Island, British Columbia, to Oakland, California.

Harvey, Notice of a collection of algae, etc., 1862*a*, pp. 160, 161, 176; Collins, Mar. Alg. Vancouver Island, 1913, p. 103; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 224. *Conferva glaucescens* Griffiths, *in* Wyatt, Alg. Danm., no. 195.

The above description is from Collins' Green Algae of North America (1909, p. 336), and refers to the species on the Atlantic coast. Its occurrence on our coast rests largely on the authority of Harvey, who determined a plant collected by Dr. Lyall at Nanaimo, B. C. There is but a single plant in Harvey's herbarium to represent the species on our coast, and one of us (Setchell) has seen the specimen and expresses some doubt as to its identity with the Atlantic coast plant. We are inclined, however, to refer here a plant collected by one of us (Gardner, no. 2647) in the warm salt water pond at the Key Route Power House in Oakland, California.

16. **Cladophora Stimpsonii** Harv.

Plants loosely tufted, up to 30 cm. high, light green, of delicate and silky texture; filaments 100–150μ at the base, tapering gradually upward, di- trichotomously divided, branches continuously but distantly forking, successively smaller, ultimate branches lateral, secundly pectinate with long ramuli, 20–25μ diam., with rounded or slightly pointed tips; segments 5–8 diam. long, longest near the base.

On shells, etc. Ucluet Inlet, Vancouver Island, British Columbia, to southern California.

Harvey, Characters new alg., 1859*a*, p. 333; Collins, Green Alg. N. A., 1909, p. 338, Mar. Alg. Vancouver Island, 1913, p. 104; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 729.

As Collins remarks (1909, p. 338), this is "a soft, delicate, silky plant, reminding one of the more delicate forms of *C. gracilis,* but distinct in manner of branching, substance and cell dimensions." It seems possibly a not unusual plant about San Pedro, California. We have compared our plants with a specimen collected by Yendo at Hakodate, Japan, the type locality, and it certainly seems to come very close to it, although careful study of a larger series of specimens might show some essential differences.

17. **Cladophora delicatula** Mont.

Plants loosely tufted, soft, dull green, about 10 cm. high; filaments 40–60μ diam. below, 4–6 diam. long; loosely branching, branches virgate, erect; ramuli in short, secund series, seldom over 8 segments in length, segments 20–30μ diam., 1–2 diam. long, joints somewhat constricted.

Growing on rocks along high water limit exposed to the surf. San Pedro, California.

Montagne, Crypt. Guyan., 1850, p. 302; Collins, Green Alg. N. A., 1909, p. 337; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1582.

The reference of these delicate plants to *Cladophora delicatula* is on the authority of Collins. He is also inclined to refer here, with some doubt, plants collected on shaded, sandstone rocks in quiet water at Coos Bay, Oregon (Gardner, no. 2747).

14. **Spongomorpha** Kuetz.

Plants composed of profusely branched, monosiphonous filaments, with terminal segments frequently larger and longer than the segments below, and usually blunt and rounded, though acute in some species; intercalary divisions predominate, though divisions of the apical segments may occur; in age the filaments are usually bound tightly together in cushion-like or rope-like tufts by descending rhizoidal branches below, or by special, short, spine-like or hooked branches, segments uni- or plurinucleate; chromatophore either a thin, closed band, or a finer or coarser reticulum with few to many pyrenoids.

Kuetzing, Phyc. Gen., 1843, p. 273. *Cladophora* (*Spongomorpha*) Kuetzing, Spec. Alg., 1849, p. 417.

As originally founded by Kuetzing, *Spongomorpha* included two species, *Conferva uncialis* Ag. and *Conferva aggregata* Ag., the latter now considered to be a synonym of *Conferva lanosa* Roth. Since these two species have generally been regarded as varieties of one, we may say that *Spongomorpha* Kuetzing has for its type *S. lanosa* (Roth) Kuetzing. In the Phycologia Germanica (1845, p. 237), Kuetzing credited *Spongomorpha* with nine species, six of which are now referred under *Spongomorpha lanosa* or its variety *uncialis,* while three are members of the Ectocarpaceae. He also placed the genus near *Ectocarpus* and well removed from his *Cladophora* and *Aegagropila.* In the Species Algarum (1849, p. 387 *et seq.*), Kuetzing placed both *Spongomorpha* and *Aegagropila* as subdivisions (subgenera?) under *Cladophora.* In this arrangement he extended *Spongomorpha* to embrace twenty-one species, but did not include under this subdivision his section "*Comosae*" (1849, p. 389) of six species now generally referred to *Spongomorpha arcta.* Kuetzing's extension, however, is sufficient to indicate a conception decidedly advanced beyond his first proposal. His first conception (1843) of the character of *Spongomorpha* was the dense habit, but later (1849) he called attention to the slender, descending rhizoidal branches. In 1854, Kuetzing reviewed *Spongomorpha* as a genus, illustrating the various species belonging to it (1854, p. 16 *et seq.*, and 1855, p. 29). Kuetzing's idea, even then, was founded chiefly on habit.

J. G. Agardh (1846, p. 12) founded a genus *Acrosiphonia* ("*Acroliphonia*" as printed) which was based largely upon *Conferva lanosa* Roth and *C. arcta* Dillw. The chief character given is that of having the upper segments long, while the lower are very short.

We find, therefore, two genera, or generic conceptions, of practically the same content, but which have usually been included under *Cladophora.* Kjellman was the first to recall attention to *Spongomorpha* (1883, p. 304 *et seq.*), but in 1893, he reviewed J. G. Agardh's genus *Acrosiphonia* and substituted it for *Spongomorpha.* A later proposal is that of Wille (1899, p. 281, 1900, p. 238) who would restrict *Spongomorpha* to the original type species, *S. lanosa,* on account of its uninucleate segments, and apply *Acrosiphonia* to the other species because of their multinucleate segments. To this distinction he adheres in a later article (1909, pp. 117, 118). It seems to us desirable to defer judgment on the value of the nuclear char-

acters until more extensive investigations have been undertaken. None of our species has been subjected to an examination of this sort, although they all seem to be made up of multinucleate segments. We shall consequently adopt *Spongomorpha* for our species instead of following the revision of Wille and adopting *Acrosiphonia.*

Kjellman (1893) has laid great stress on the variation in the position of the fertile segments. We have not been able, as yet, to study this character in many of our species and can not, therefore, judge properly of distinctions founded on such characters. It is very desirable that a study of the forms, arrangement and dates of formation of the fertile segments be made for our various species, and in widely separated localities.

We have followed Collins (1909) very largely in the descriptions and limitations of our species, but have examined all our west coast plants carefully. As a result, we have found it necessary to depart from his account in some minor details and to differ from him in referring some of our plants. Of the seven species recognized by us, five are supposedly restricted to the North Pacific Ocean and originally named by Ruprecht (as species of *Conferva*). Two, however, are assumed to be identical with North Atlantic species. Possibly some of our species may be identical rather with some of the species distributed by Kjellman under *Acrosiphonia,* but we have not been able to make sufficiently certain of this to place any under his names.

The species of our coast are most numerous along the northern range, i.e., from Puget Sound northward. *Spongomorpha coalita,* however, ranges from Sitka, Alaska to just north of Point Conception, California. A form referred to *Spongomorpha arcta* has been found in one locality in this same range, but we are inclined to associate it rather with *S. Mertensii.*

Key to the Species

1. Branches all blunt and rounded at the apex 2
1. Branches sometimes rounded, sometimes acute at the apex 5
   2. Hooked branchlets present ..... 5. **S. Mertensii** (p. 227)
   2. Branchlets never hooked 3
3. Slender, not over 100μ in diam. at tip ..... 1. **S. arcta** (p. 223)
3. Stouter, 200μ, or over, in diam. at tip 4
   4. Walls of segments thin, not striate ..... 2. **S. Hystrix** (p. 224)
   4. Walls of segments thick, striate ..... 3. **S. duriuscula** (p. 225)
5. Hooked branchlets absent ..... 4. **S. saxatilis** (p. 226)
5. Hooked branchlets present 6
   6. Hooked branchlets always simple ..... 6. **S. spinescens** (p. 229)
   6. Hooked branchlets usually compound or branched ..... 7. **S. coalita** (p. 230)

1. **Spongomorpha arcta** (Dillw.) Kuetz.

Plants rich green, in dense fastigiate tufts, up to 15 cm. high; filaments erect, stiff, 60–100μ diam. above, below smaller, much branched; branches erect or appressed, obtuse or clavate at tips; segments above 4–6 diam. long, below 1.5–3 diam. long; rhizoidal descending branches 40–60μ diam. with segments 2–6 diam. long, firmly matting together the lower part of the tuft.

On rocks and on *Fucus* in the middle and lower littoral belts. Alaska (Bering Sea) to Washington (Puget Sound).

Kuetzing, Sp. Alg., 1849, p. 417; Collins, Green Alg. N. A., 1909, p. 359 (excluding varieties). *Conferva arcta* Dillwyn, Brit. Conf., 1809, p. 67, pl. E. *Cladophora arcta* Kuetzing, Phyc. Gen., 1843, p. 263; Harvey, Phyc. Brit., vol. 2, 1849, pl. 135; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 224 (in part and excluding varieties except in part). *Cladophora lanosa* var. *uncialis,* Tilden, Amer. Alg. (Exsicc.), no. 372 (not of Thuret).

We have referred a number of specimens to *Spongomorpha arcta,* but without any knowledge of the exact nature of the type. The type specimens came from Bantry Bay, on the southwest coast of Ireland, and seem to be plants all of whose filaments are slender, obtuse or clavate at the tips, decidedly matted together below by descending rhizoidal branches but free and spreading in the upper portions. Neither hook nor spine branchlets are present. The plants referred here from our territory correspond in these general details and are, at least, closely related to this species. We are left with the impression, however, that this may be the conception of a group of species rather than of a single specific entity.

We have been unable to divide the *Spongomorpha arcta* of our coast into the varieties given by Collins in The Green Algae of North America (1909, pp. 359, 360). His f. *conglutinata,* based chiefly on the separation of groups of terminal filaments into "Symploca-like tufts" and said to have "acute branches occasionally found at the base of the older plants," proves to have, on careful examination of the plants on which it is based, and which show the characteristic habit, not only spiny branchlets but simple hooked branchlets as well. We feel compelled, therefore, to refer these plants rather to *Spongomorpha spinescens,* at least as we understand that species in this account. We find a similar combination of spiny branchlets and hooked branchlets in no. 918 of Collins, Holden and Setchell's Phyco-

theca Boreali-Americana referred to f. *pulvinata*. This plant also is referred by us to *S. spinescens*. While specimens of what we retain under *S. arcta* have also been referred to these varieties, they differ in habit from that described for either variety and we consequently refer them to *S. arcta* without attempting any varietal distinction.

It has been customary to refer under *Spongomorpha arcta,* at least in the broader sense in which we are, at present, compelled to use the name, *Conferva cohaerens* of Ruprecht (1851, p. 402). Ruprecht, himself, says that it is probably only a subspecies of *C. arcta*. The type specimens of *C. cohaerens* came from the North Pacific Ocean, probably from "Awatschabai" in the Sea of Ochotsk. Ruprecht states that his *Conferva cohaerens* is to be only slightly distinguished from the British *C. arcta* (of Mrs. Griffiths) by having the thicker variegated lateral branchlets which are abruptly attenuated to a point of $\frac{1}{200}$ line (about 11.3μ) in diameter (main filaments 75–80μ). *C. cohaerens* also differs particularly from *C. saxatilis* Rupr. in its intertwined filaments and its lower, more slender and shorter branchlets. The type specimen of *C. cohaerens* in the Herbarium of the Imperial Academy of St. Petersburg has the appearance and habit of *Spongomorpha arcta*, but it is very desirable that it be carefully examined microscopically before being finally referred.

2. **Spongomorpha Hystrix** Stroemf.

Plants rich green, in rather dense tufts, filaments straight, very erect, except those at the base of the tuft, which are somewhat more open; about 100–300μ diam. at the base, 200–500μ diam. at the tip ultimate segments blunt or clavate, not attenuate; segments up to 4 diam. long at the tip, 0.5–1.5 diam. long below; rhizoidal branches fairly common in the older parts, 40–70μ diam., segments 3–10 diam. long.

Forming a dense mass on rocks in the littoral belt. From Agattu Island to Sitka, Alaska.

Stroemfelt, Om Algvegt. vid Island Kuster, 1887, p. 54; Collins, Green Alg. N. A., 1909, p. 358; not Setchell and Gardner, Alg. N.W. Amer., 1903, p. 226.

Spongomorpha Hystrix seems to be a high northern species of the *arcta* group, differing primarily from *Spongomorpha arcta* in the greater diameter of the filaments. The specimens referred by us in our final disposition of the species, have much larger filaments than

those of *S. arcta* (up to 200μ or over at the tips), but we have seen none approximating the maximum diameter (500μ at the tips) given for the Atlantic-Arctic plants. The Tilden specimens (American Algae, no. 374), issued as *Cladophora arcta* form *b*, and assigned to *C. Hystrix* by Setchell and Gardner (1903, p. 226), prove on examination to have compound hooked branchlets and have been assigned, consequently, to *Spongomorpha coalita* in this account. Specimens from Karluk and from Uyak Bay, Alaska, assigned by Setchell and Gardner to *Cladophora arcta* and its form *conglutinata* are now referred here, after careful examination. The status of this species on our coast, however, is subject to careful revision as soon as more abundant material for study and comparison is available.

Spongomorpha Hystrix might be compared with *S. duriuscula*, so far as description goes, but the species are very different in aspect, the former being closely matted together below, while the latter shows so loose an intermingling of the filaments as to suggest the possibility of its belonging rather to *Cladophora* than to *Spongomorpha*. The segments also in *S. duriuscula* are usually shorter and those of the main filaments are horizontally striate.

3. **Spongomorpha duriuscula** (Rupr.) Collins

Tufts 15–25 cm. high, erect, loose, main filaments firm, straight, with thick, horizontally striate walls, 200–250μ diam. below, 300μ at the tip; segments 0.5–1.5 diam. long, 2–3 diam. at the blunt tips; branches similar, erect, scattered or in secund series of two or more; near the base of the tuft more slender, 150–200μ diam., with thinner walls, not striate, with numerous short, patent ramuli, scattered or secund.

Growing on rocks in the upper sublittoral and lower littoral belts. Alaska (Pribilof Islands to Karluk).

Collins, Green Alg. N. A., 1909, p. 357. *Cladophora alaskana* Collins, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 917 (nomen nudum), *in* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 228 (description). *Conferva duriuscula* Ruprecht, Tange, 1851, pp. 401–404. *Conferva cartilaginea* Ruprecht, Tange, 1851, p. 404 (fide Yendo). *Acrosiphonia duriuscula* Yendo, Notes on algae new to Japan, V, 1916, p. 246.

The type locality of *Conferva duriuscula* Ruprecht is Unalaska, where it was collected by Wosnessenski (no. 108) as the type specimen

shows. The type specimen is of exactly the same habit and appearance as the specimens distributed under no. 917 of Collins, Holden and Setchell's Phycotheca Boreali-Americana, which are topotypes, probably collected at the very same spot whence Wosnessenski obtained the type.

Spongomorpha duriuscula is a coarse, lax species whose filaments are so slightly bound together that the plant seems much less like a *Spongomorpha* than either of the preceding species. There are some slender rhizoidal branches, however, and the main filaments increase in diameter towards their summits. The walls of the segments of the main filaments and longer branches are thick and horizonally striate as Ruprecht has stated. It seems to be a very distinct species of the Upper Boreal Zone.

Yendo (1916, p. 246) has placed this species under *Acrosiphonia* and, after examining the types, has united with it *Conferva cartilaginea* Ruprecht (1851, p. 404) whose type locality is also Unalaska. He also refers here Tilden's no. 373 (Amer. Alg.) under *Cladophora arcta*. The two ("a" and "b") specimens in our copy are, however, clearly *Spongomorpha coalita*, both as to habit and as to the possession of compound hooked branchlets. Yendo states that Kjellman (1889, p. 55) included plants of this species under his *Cladophora diffusa* from Bering Island, Siberia.

4. **Spongomorpha saxatilis** (Rupr.) Collins

Plants dense but not much matted together; filaments 80–120μ diam., about the same diameter throughout, segments below 1–3 diam. long, above 3–6 diam., terminal segments sometimes 10–12 diam.; branching di- trichotomous, with occasional lateral branches, divisions erect, somewhat acute or tapering, but usually with rounded tip; older parts with descending rhizoidal filaments, about half the diameter of the filaments from which they spring, and with longer segments sometimes 10–12 diam. long.

On rocks in the lower littoral belt. Alaska to San Francisco, California.

Collins, Green Alg. N. A., 1909, p. 360, Mar. Alg. Vancouver Island, 1913, p. 104. *Conferva saxatilis* Ruprecht, Tange, 1851, p. 403. *Cladophora saxatilis* (Rupr.) De-Toni, Syll. Alg., vol. 1, sect. I, 1889, p. 311; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 223; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 921. *Cladophora arcta* Tilden, Amer. Alg. (Exsicc.), no. 279 (not of Kuetzing).

Spongomorpha saxatilis var. **Chamissonis** (Rupr.) Collins

Filaments 40–60μ diam., cells 3–4 diam. long, nodes constricted; cells slightly shorter towards the base.

Alaska to Washington.

Collins, Green Alg. N. A., 1909, p. 360. *Cladophora Chamissonis* (Rupr.) De-Toni, Syll. Alg., vol. 1, sect. I, 1889, p. 333; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 920. *Conferva Chamissonis* Ruprecht, Tange, 1851, p. 403.

Spongomorpha saxatilis resembles looser conditions of *S. arcta,* but is even more lax, as a rule, than any condition of that species. It resembles *S. spinescens* in having very much attenuated branches and even moderately sharp branchlets, but it never has hooked, acute, tipped branchlets. It is also more lax and less split up into symplocoid tufts than is usual with the *S. spinescens* of our coast.

The type of *Conferva saxatilis* Ruprecht was found at "Cap Nichta" in the Sea of Ochotsk, and the other specimens referred to it seem to differ from it and among themselves in coarseness and proportions of segments. Yendo, who has examined the type specimens of Ruprecht's species of *Conferva,* refers (1916, p. 245) *Conferva Chamissonis* and *C. saxatilis* to the same species, as Collins had already done. Collins, however, was inclined to add *Conferva Mertensii* and *C. viminea* as well, but Yendo says that while the type specimens in St. Petersburg show that the two latter are identical they also show that they are quite distinct from the two former. We, also, have felt it necessary to keep *C. Mertensii* separate from *C. saxatilis.*

5. **Spongomorpha Mertensii** (Rupr.) S. and G.

Plants up to 11 cm. high, erect, moderately rigid, lax, bright green; branching alternate, branches erect, angles acute; main filaments and branches 110–160μ diam. above, 80–110μ diam. below; segments 0.5–2.5 times as long as the diameter, terminal rounded or gradually tapering, even prolonged into long spinous rhizoids, up to 5 times as long as the diameter; spiny branchlets absent; short, blunt, branched, hooked branchlets generally present.

Alaska (Unalaska and Sitka) to California (San Francisco).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 280. *Conferva Mertensii* Ruprecht, Tange, 1851, p. 403. *Conferva viminea* Ruprecht,

loc. cit. (fide Yendo). *Cladophora Mertensii* De-Toni, Syll. Alg., vol. 1, 1889, p. 317. *Cladophora viminea* De-Toni, *loc. cit.*, p. 318. *Spongomorpha arcta* var. *limitanea* Collins, Green Alg. N. A., Suppl. I, 1912, p. 97, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1736. *Acrosiphonia Mertensii* (Rupr.) Yendo, Notes on algae new to Japan, V, 1916, p. 246.

Collins (1909, p. 360), on evidence furnished by authentic specimens in Herbarium Farlow, unites not only *Conferva Mertensii* Rupr. with *C. viminea* Rupr., but also unites with them *C. Chamissonis* Rupr. and *C. saxatilis* Rupr., placing all these names as synonyms under *Spongomorpha saxatilis*. Yendo (1916, p. 245), however, as a result of study of the type specimens preserved in the Herbarium of the Imperial Academy of Sciences of St. Petersburg, is of the opinion that *Conferva saxatilis* and *C. Chamissonis* are simply forms of one species and that *C. Mertensii* and *C. viminea* are also forms of one species, but that the two latter are quite distinct from the two former. Yendo does not, however, point out in what this difference consists.

We are inclined to refer here provisionally and with considerable doubt, a specimen (no. 3288 of Setchell and Lawson) collected at Amaknak Island in the Bay of Unalaska. It is somewhat coarser than specimens of *Spongomorpha saxatilis* and of even more lax habit. It has no spines, but has occasional inrolled, circinate, yet blunt, branchlets, very different, however, from the hooked branches of either of the two succeeding species. The general aspect, the dimensions, and these inrolled branchlets are all indicated in Ruprecht's description of *Conferva Mertensii* and assist in distinguishing this species from *C. saxatilis*.

Very similar to the Unalaska plant is that distributed under no. 1736 of the Phycotheca Boreali-Americana. It has no spiny branches or branchlets but it usually shows circinate, often branched, branchlets. The terminal segments vary from very blunt and dilated to extremely attenuated and in some plants are prolonged into curious long and sinuate rhizoids. The last character has been noticed only in summer plants. We may add that the description of this species has been drawn up largely from our Californian specimens.

The type locality for *Conferva Mertensii* Rupr. is given as Sitka, while *C. viminea* Rupr. is given as occurring at both Sitka and Unalaska.

6. **Spongomorpha spinescens** Kuetz.

Plants orbicular in outline, with short symplocoid divisions; filaments about 80μ diam. below, 100μ diam. at tip; segments 0.5–1 diam. long below, 2 diam. long at tip; normal, erect, somewhat obtuse branches abundant; also patent and acute branches, either short and spine-like, or long, hooked, revolute and circinate, uniting the filaments into branching symplocoid tufts; descending rhizoidal branches slender and abundant.

Growing on the tips of algae and sponges along the upper tide limit in exposed places. Bay of Unalaska, Alaska, to Coos Bay, Oregon.

Kuetzing, Tab. Phyc., vol. 4, 1854, p. 16, pl. 75, II; Collins, Green Alg. N. A., 1909, p. 360. *Cladophora spinescens* Kuetzing, Sp. Alg., 1849, p. 418; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 227. *Cladophora saxatilis* Setchell and Gardner, *loc. cit.*, p. 223 (in part). *Cladophora arcta* f. *pulvinata* Collins, *in* Setchell and Gardner, *loc. cit.*, p. 225. *Spongomorpha arcta* f. *pulvinata* Collins, Green Alg. N. A., 1909, p. 360 (not of Foslie). *Cladophora arcta* f. *conglutinata* Collins, *in* Setchell and Gardner, *loc. cit.*, p. 225 (in large part). *Spongomorpha arcta* f. *conglutinata* Collins, Green Alg. N. A., 1909, p. 359. *Cladophora arcta* Harvey, List N.W. Alg., 1862*a*, p. 176 (at least in part). *Cladophora scopaeformis* Setchell and Gardner *loc. cit.*, p. 227 (in part).

Spongomorpha spinescens was founded on a specimen sent by Lenormand to Kuetzing from the coast of Morbihan, a department of France on the northern short of the Bay of Biscay. A topotype of this species, if not possibly a cotype, exists in the Herbarium of the University of California (no. 145264), i.e., it is from the same locality and sent out by Lenormand. It also answers in full to Kuetzing's description.

Spongomorpha spinescens is characterized by abundant acute branches and branchlets with some of the short, simple, acute branchlets curved into definite hooks. In looking over our Alaskan and Puget Sound materials, we find a number of specimens which correspond well in habit and other characters with the descriptions and figures of *S. spinescens* as well as with the specimen mentioned above. We feel fairly certain in referring them to Kuetzing's species. We have also compared our specimen with the descriptions of *Acrosiphonia albescens* Kjellman and *A. hamulosa* Kjellman as well as with speci-

mens of the former from both Iceland (Jónsson) and the Faeröes (Börgesen). Our plants do not agree completely with the description of either of Kjellman's species nor do they correspond to either of the specimens of *A. albescens* which specimens, in their turn, seem to us to belong to different species.

We find that our specimens, seeming to belong to this species, have been variously referred in our previous paper (1903) as will be seen from the synonymy given above. It is to be easily distinguished from the next, both in habit and in the unbranched, simple, hooked branchlets. The fertile segments are all intercalary, usually one or two together, and rarely three to four in a series, and generally distributed over the plant.

7. **Spongomorpha coalita** (Rupr.) Collins

Plate 16, fig. 4, and plate 32

Plants elongated, at first loosely tufted, but soon forming long, dense, ropelike, branching tufts, up to 30 cm. long: at first bright, later dull or yellowish green; filaments 100–250μ diam. in the terminal segment; branching dichotomous below, irregularly alternate above, all branches of this class erect, with blunt, truncate, or, at times, acute ends; also present, except in very young plants, abundant, patent, tapering, very acute, compound, or branched, sharply and abruptly hooked branches by which all the older parts are densely matted together; segments 0.3–1 diam. long in the lower part of the older plants, 2–3 diam. in the younger plants, and even 6–25 diam. in the active terminal segment.

Growing on rocks and on other algae in the middle and lower littoral belts. Very abundant along the entire Pacific Coast from southeastern Alaska (Sitka) to central California (San Luis Obispo County).

Collins, Green Alg. N. A., 1909, p. 361. *Cladophora scopaeformis* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 227; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), nos. 819 and 922; Farlow, Anderson and Eaton, Alg. Exsicc. Amer.-Bor., no. 203. *Cladophora coalita* Setchell and Gardner, *loc. cit.*, p. 227. *Cladophora Hystrix* Setchell and Gardner, *loc. cit.*, p. 226 (not of Stroemfelt). *Conferva coalita* Ruprecht, Tange, 1851, p. 404. *Cladophora arcta* form *a*, Tilden, Amer. Alg., no. 373, and form *b*, no. 374; Collins, Mar. Alg. Vancouver Island, 1913, p. 104, as to no. 374.

Spongomorpha coalita, as it usually occurs, is readily recognizable, both by its habit and by the possession of compound, strongly hooked branchlets. It seems reasonably certain that the *Conferva scopaeformis* Ruprecht represents only a younger stage of *C. coalita* Ruprecht, with somewhat more slender filaments and longer terminal segments (cf. Collins, 1909, p. 361). The plants are distinctly elongated and their filaments are combined into ropelike masses. The recurved branchlets usually show either three or four sharply recurved and pointed tips or a less number, sometimes only one, with one or more longer straight branchlets arising from them. We have seen nothing like this in any other of our species of *Spongomorpha,* nor is any branching of this sort described for any of the species of this genus, or of *Acrosiphonia,* except that Kjellman figures compound recurved branchlets in his *Acrosiphonia hamulosa* (1893, pl. 1, f. 5). This species, however, is of very different habit, and has more slender filaments as well as more slender recurved branchlets than *Spongomorpha coalita,* resembling more closely *S. spinescens,* but seemingly distinct from it.

There is considerable variation in the dimensions of the filaments and in the proportions of the segments in different individuals. The walls of the segments also vary much in thickness, up to as great as 40μ, e.g., in a specimen collected on the west coast of Whidbey Island, Washington (Gardner, no. 467).

A seemingly young, but unusual plant, collected on June 3 at Carmel Bay, California (no. 5418 Setchell), is about 200μ in diameter at the tips, but the terminal segment is often as much as 3 mm. long. Below, the hooked branchlets are often simple, but some are compound. If separated, these specimens might be referred under *Conferva scopaeformis* Rupr.

15. **Microdictyon** Dec'ne

Plant a sessile, membranaceous network, formed of monosiphonous filaments, densely branching in one plane in a radiate manner, the tips of the branches attaching themselves to the sides of other branches by a terminal thickening, producing irregular, angular, open spaces between the segments; reproduction by zoospores formed in any segment.

Decaisne, Pl. de l'Arab., 1841, p. 115.

The genus *Microdictyon* comprises species which are totally different in habit from any of the other Cladophoraceae, and possesses a thallus of a leaflike form and general appearance. The species may, however, be considered to represent opposite branched Cladophorae whose branchlets anastomose to produce a plane, reticulate thallus, the main filaments and branches giving the appearance of veins, while the branchlets form the general groundwork. The species are all tropical or subtropical, one species only being credited to our coast.

Microdictyon Agardhianum Dec'ne

Plants delicately membranaceous, filaments 50–200μ diam., main veins rather distinct, radiate, branches patent; segments usually 2–4 diam. long.

Guadalupe Island, Lower California.

Decaisne, Pl. de l'Arab., 1841, p. 115.

Collins (1909, p. 366) refers under the name *Microdictyon Agardhianum* a plant from Guadalupe Island off the coast of Mexico. Since we have not seen specimens of this, we have not attempted to consider whether the Guadeloupe plant is the same as *M. Agardhianum* Decaisne of the Red Sea or *M. umbilicatum* (Velley) Zanard. from southwest Australia, but have left our reference under the name used by Collins.

16. **Boodlea** Murray and De-Toni

Boodlea composita (Harv.) Brand (1904, p. 187, pl. 6, f. 28–35) is a tropical species, the type locality of which is the island of Mauritius. This species has been credited to our coast (cf. Setchell and Gardner, 1903, p. 226; Collins, 1909, p. 367; Yendo, 1916, p. 247; Collins, Holden and Setchell, Phyc. Bor.-Amer., no. 722). An examination of the specimens upon which this representation is based shows, however, that none of them is really the *Conferva composita* Harv. (1834, p. 157). Collins (1918, p. 85) states that what has been said concerning *Boodlea composita* in his Green Algae of North America (1909, p. 367) is to be cancelled. *Boodlea,* consequently, can not be said to have been found on our coast.

Order 4. ULVALES Blackman and Tansley

Fronds membranaceous of one or two layers of cells, or tubular with wall of a single layer of cells, or filamentous of two or more vertical rows of cells, simple or branched, attached by rhizoids either free or united into a disk; cells with a single nucleus and a single parietal chromatophore containing usually one, but, occasionally, two or three pyrenoids; multiplication vegetative, non-sexual and sexual; vegetative, by abscission of proliferous shoots, by accidental rupture, by gemmae or by akinetes; non-sexual, by 2- or 4-ciliated zoospores; sexual by 2-ciliated isoplanogametes forming a zygote capable of germinating at once.

Blackman and Tansley, Rev. Class. Green Algae, 1902, pp. 20 and 136; West, Algae, 1916, vol. 1, p. 275.

family 9. ULVACEAE greville

Characters of the order.

Greville, Alg. Brit., 1830, p. 168 (lim. mut.). *Ulvacées* Lamouroux, Essai, 1813, p. 59 (in part); Thuret, Note sur la Syn., 1854, p. 27.

Key to the Genera

1. Frond tubular even at maturity 2
1. Frond expanded at maturity 4
2. Frond parenchymatous (**except E. groenlandica**) ..... 19. **Enteromorpha** (p. 244)
2. Frond not parenchymatous 3
3. Cells gloeocapsoid in longitudinal strips ..... 17. **Capsosiphon** (p. 233)
3. Cells neither gloeocapsoid nor in longitudinal strips ..... **Enteromorpha groenlandica** (p. 248)
4. Frond narrow, 1-4 cells wide ..... 21. **Percursaria** (p. 273)
4. Frond broad, membranaceous 5
5. Mature frond of a single layer of cells ..... 18. **Monostroma** (p. 235)
5. Mature frond of two layers of cells, united wholly or in part ..... 20. **Ulva** (p. 260)

17. **Capsosiphon** Gobi

Plants filamentous, hollow, gelatinous, the cells mostly in twos and fours, enclosed within the walls of the mother cell, and arranged in distinct longitudinal series, the series loosely connected laterally.

Gobi, Ber. Alg. Forsch. im Finn. Meer., 1877, etc., 1879, p. 88. *Ilea* Fries, Syst. orb. veg., pt. 1, pl. homon, 1825, p. 336 (in part); J. G. Agardh, Till Alg. Sys., pt. 3, 1883, p. 114.

We have preferred to use the generic name *Capsosiphon* of Gobi (1879) rather than *Ilea* J. Ag. for several reasons. Fries founded the genus *Ilea* in 1825 (p. 336) to contain various species which were later found to belong to *Enteromorpha* Link (1820). The genus *Ilea* was refounded by Fries in 1835 (p. 321) to contain two species, viz., *I. Fascia* (Muell.) Fries and *I. foeniculaceus* (Huds.) Fries. If the genus *Ilea* is to be retained at all, it ought to be retained for *Ilea Fascia* (*Phyllitis Fascia* Kuetz.), since Fries states (1835) that the character of *I. Fascia* was the one upon which the genus was really founded. Finally the genus *Capsosiphon* Gobi (1879) was founded two to three years before J. G. Agardh (1883, p. 114) resurrected the name *Ilea* to confer it upon the *Ulva aureola* Ag. (1835, no. 29, pl. 29).

Capsosiphon fulvescens (Ag.) S. and G.

Fronds 1–5 cm. up to 8 cm. high, thread-like, later becoming tubular, up to 2 cm. diam., cylindrical or somewhat compressed, with an occasional swelling, unbranched, or in age slightly proliferating; cells roundish or oval with a thick membrane resembling the cells of *Glococapsa*, 4–5μ diam., arranged in long rows, 2–4 rows grouped together.

Growing on muddy rocks. St. Michael, Alaska.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 280. *Ulva fulvescens* Agardh, Sp. Alg., 1821, p. 420. *Ilea fulvescens*, J. Agardh, Till Alg. Syst., part 3, 1883, p. 115, pl. 4, f. 95–99; Collins, Green Alg. N. A., 1909, p. 206, f. 71. *Enteromorpha aureola* Kuetzing, Tab. Phyc., vol. 6, 1856, p. 14, pl. 40; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 214. *Capsosiphon aureolum* (*sic!*) Gobi, *loc. cit.* *Ulva aureola* Agardh, Icon. Alg. Eur., 1835, no. 29, pl. 29.

Capsosiphon fulvescens, better known perhaps as *Enteromorpha aureola*, was included in our previous account (1903, p. 214) as having been found at St. Michael, Alaska by one of us (Setchell) intermixed with *Rhizoclonium riparium*. The specimen, on reëxamination, fails to show a single filament of the *Capsosiphon*, hence its proper inclusion in our flora must remain, for the present, a matter of doubt.

We have chosen the specific name *fulvescens* rather than that of *aureolus*, because J. G. Agardh (1883, p. 115) has stated that it belongs to this species, *Ulva fulvescens* Ag. being a younger condition, while *U. aureola* Ag. is more developed.

18. **Monostroma** Thur.

Frond at the beginning a closed sack or tube, at times splitting very early or again retaining the saccate or tubular shape until late, in almost all cases, however, finally becoming a flattened or crisped membrane of a single layer usually parenchymatous but occasionally of gloeocapsoid cells, except at the base where thickening occurs by the descent of elongated rhizoidal cells forming several layers; vegetative multiplication by gemmation or proliferation, non-sexual reproduction by 2- or 4-ciliated zoospores and sexual reproduction by 2-ciliated isoplanogametes all originating in unchanged cells; zygote usually germinating immediately.

Thuret, Note sur la Syn. des Ulv., 1854, p. 13.

The genus Monostroma comprises those members of the Ulvaceae which, at maturity, form an expanded membrane of a single layer of cells. Certain species of *Monostroma* develop nearly to full size as sacks which then split open by one or more slits and become expanded membranes. There are still other species, however, which seem to consist of expanded membranes of a single layer of cells almost, if not quite, from the beginning. We have some reason to suppose that these species are tubular or saccate only in their very youngest stages, splitting early and becoming, therefore, one-layered almost from the beginning.

In some of the species of *Monostroma* the cells are closely placed, with thin, or even thicker, firm walls, giving a parenchymatous appearance, while in others the intercellular substance is ample and more or less gelatinous causing the cells to stand off from one another, usually in small groups (2–4 or more) after the fashion of *Gloeocapsa* or *Chroococcus*. The relative sizes of the cells in different dimensions, as well as the abundance or scarcity of intercellular substance, added to the size, development, and shape of the frond, furnish characters which may be used for the separation of the species.

The species of *Monostroma* are marine, and also found in brackish and fresh water. At times what appears to be the same species may be found in both salt and fresh water. The thirty-five species credited to the genus are known only with certainty from the Northern Hemisphere, where they occupy, for the most part, the colder waters, intruding into warmer zones only in winter and spring when the temperature of the water is lowered.

Key to the Species

1. Frond saccate until late, then rupturing 2
1. Frond expanded very early 3
2. Membrane 15–20μ thick, delicate in texture ..... 1. **M. Grevillei** (p. 236)
2. Membrane 25–45μ thick, tougher ..... 2. **M. arcticum** (p. 238)
3. Frond light green on drying, adhering well to paper 4
3. Frond darkening on drying, not adhering well to paper ..... 8. **M. fuscum** (p. 242)
4. Membrane 40–50μ thick ..... 7. **M. orbiculatum** (p. 242)
4. Membrane less than 30μ thick 5
5. Frond 7–10μ thick 6
5. Frond 20–25μ thick 7
6. Membrane distinctly areolate, cells distinctly grouped ..... 4. **M. areolatum** (p. 240)
6. Membrane not areolate, cells slightly, if at all, grouped ..... 3. **M. zostericola** (p. 238)
7. Cells arranged in distinct groups of 4–6, rounded ..... 5. **M. quaternarium** (p. 240)
7. Cells not in distinct groups, angular ..... 6. **M. latissimum** (p. 241)

1. **Monostroma Grevillei** (Thur.) Wittr.

Frond attached, at first saccate, then opening at the top, and ultimately splitting to the base; soft and delicate, pale green; membrane 15–20μ thick, cells quadrate with rounded angles, closely set, horizontally oval in cross section, 12–14μ high; sporiferous cells enlarged, vertically elongate in cross section; cell wall dissolving after emission of spores.

On stones in the upper sublittoral and lower littoral belts, Alaska.

Wittrock, Monostr., 1866, p. 57, pl. 4, f. 14; Collins, Green Alg. N. A., 1909, p. 209; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 208. *Enteromorpha Grevillei* Thuret, Note sur la Syn. Ulv., 1854, p. 25.

Certain of the species of *Monostroma* retain the saccate habit until late, or rather until the sack has reached considerable size, before splitting. Two species, at least, on our coast do this; one is *Monostroma Grevillei* and the other is *M. arcticum*. In *M. Grevillei*, especially if obtained in position, the saccate habit is usually easily observed or inferred, even when the plant is split to the base into segments. When detached fragments, especially of some size, are collected, the saccate habit may not be in evidence. *Monostroma Grevillei* is of delicate consistency and lubricous, differing in both these characters from any of the forms of *M. arcticum*. It is also decidedly thinner than *M. arcticum*. Otherwise the two species are much alike. Rosenvinge (1893, p. 949 and 1894, p. 152) has united them as varieties of one species. We are inclined, however, to follow

Collins (1909, pp. 209, 210) and keep them separate, at least for the present, for the reasons given above.

On the Atlantic coast of North America, *Monostroma Grevillei* is a summer plant in the Greenland waters (Upper Boreal Zone), but invades the North Temperate Zone in spring-time. On the Pacific Coast, our only specimens are from Bering Sea but Collins (1903, p. 13) states that it descends to Monterey, California, which is much above its accustomed temperature.

The reference of Collins to Monterey is based on two small specimens found attached to *Gloiosiphonia verticillaris* Farl., collected by Mrs. J. M. Weeks. Reëxamination of these specimens, although not convincing, leads as to the opinion that they may be nearer *Monostroma zostericola* than to any forms of *M. Grevillei.*

Collins gives, in addition to the typical form, the two following varieties as found on our coast. Since we have access to very scanty material we follow him and other authorities as to their disposition.

Monostroma Grevillei var. **lubricum** (Kjellm.) Collins

Frond up to 15 cm. long, pale or whitish green, delicate, very lubricous and flaccid, of irregular outline, laciniate, plicate, margin often crisped and lacerate; frond 18–22μ thick; cells seen superficially, circular or rounded angular, often in twos or fours, cell wall thick; in cross section horizontally ovate or oblong, 4.5–8μ high.

Floating in shapeless masses in quiet waters. Alaska.

Collins, Green Alg. N. A., 1909, p. 209. *Monostroma lubricum* Kjellman, Spetsb. Thall., 1877, p. 48, pl. 4, f. 8, 9; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 207.

Monostroma Grevillei var. **Vahlii** (J. Ag.) Rosenv.

More slender in form, often cylindrical, retaining its saccate shape longer, and with cells arranged in more or less distinct longitudinal series. An early spring plant.

Alaska (Kukak Bay, *Saunders,* Sitka, *Gardner*).

Rosenvinge, Groenl. Havalg., 1893, p. 949; Collins, Green Alg. N. A., 1909, p. 209. *Monostroma Vahlii* J. G. Agardh, Till Alg. Syst., VI, 1883, p. 109, pl. 3, f. 84–89; Saunders, Alg. Harriman Exp., 1901, p. 410; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 208.

We have seen only a fragment collected by one of us (Gardner) at Sitka. This seems, however, to be clearly the *Monostroma Vahlii* of J. G. Agardh.

2. **Monostroma arcticum** Wittr.

Frond attached, at first saccate, later splitting into a few broad laciniae; subradiately plicate, with crisped margin; pale green, becoming yellowish in drying; membrane 25–45μ thick; cells 4–6 angled, closely set, irregularly placed; in cross section either vertically or horizontally oval, 10–30μ high.

On stones, in shallow pools of the middle littoral belt. Known only from Alaska.

Wittrock, Monostr., 1866, p. 44, pl. 2, f. 8; Collins, Green Alg. N. A., 1909, p. 210; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 208; Collins, Holden and Setchell, Phyc. Bor.-Amer., (Exsicc.), no. 910. *Monostroma latissimum* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 207 (in part).

Rosenvinge (1893, p. 949, 1894, p. 152) unites *Monostroma arcticum* with *M. Grevillei,* keeping it as a variety. Much may be said in favor of such a disposition, especially in view of the treatment usually accorded *M. fuscum, M. splendens* and *M. Blyttii.* Collins (1909, p. 210), however, decides to keep them separate, although acknowledging the close relationship, on the ground that *M. arcticum* is a somewhat tougher and thicker plant than typical *M. Grevillei.* It seems best to us, also, to keep them separate. We follow Rosenvinge, however, in uniting with *Monostroma arcticum, M. angicava, M. cylindraceum* and *M. saccodeum* of Kjellman (1883, pp. 295–297). These last species seem to differ only in general habit and this is probably due to earlier or later splitting of the saccate frond.

We find in carefully examining some specimens from Bering Sea and northwestern Alaska, previously referred (cf. Setchell and Gardner, 1903, p. 207, as to nos. 4020 and 5077) to *Monostroma latissium,* that they agree better with *M. arcticum.*

3. **Monostroma zostericola** Tilden

Plate 14, figs. 12, 13

Frond more or less cucullate, cuneate-obovate or divided into segments of that form; cells angular, in more or less distinct series, longitudinal and transverse; margins plane, often ragged; membrane 7–10μ thick, cells quadrate to vertically oblong in cross section, 5–8μ high.

In the sublittoral belt, growing on *Zostera*. Known definitely only from the waters of the Puget Sound region.

"Monostroma zostericolum" Tilden, Amer. Alg. (Exsicc.), no. 388, 1900. *Monostroma leptodermum* Collins, Green Alg. N. A., 1909, p. 213; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 209 (probably not of Kjellman).

Monostroma zostericola is known thus far from the original collection by Tilden from the waters between Brown and San Juan Islands, Washington; from Port Renfrew, Vancouver Island, British Columbia, collected by Butler and Polley (cf. Collins, 1913, p. 103, under *M. leptodermum*); and from near Victoria, British Columbia, collected by one of us (Gardner). There is some reason for referring here, although doubtfully, young specimens from Monterey previously placed under *M. Grevillei*. The *specimens* of all collections agree in showing sessile plants, attached and split in such a way as to suggest their earlier saccate form and growing on *Zostera*. The species is very delicate and its membrane very thin. The only species of this genus on our coast with anything like so thin a membrane is our *Monostroma areolatum* which differs decidedly in size, undulate and crisped lobes, arcolate surface and cells in definitely delimited and separated groups. Collins, in various papers, has been inclined to refer the Tilden plant to *Monostroma leptodermum* of Kjellman (1877*a*, p. 52, f. 23, 24). Kjellman's plants, unfortunately, were not found attached, but were floating fragments, the largest of which was 10 cm. long and about 6 cm. wide. We have seen no entire plants among the considerable number examined from our coast which approach these dimensions. Kjellman also states that his larger fragment had the margins undulate and crisped which is not the case in any of the specimens from our coast. The cells in ours seem to agree fairly well with the description and figures of Kjellman except in being more elongated vertically than horizontally in cross section.

Rosenvinge (1893, p. 944, f. 49, 1894, p. 148, f. 49) and Jónsson (1904, p. 63) refer a very different plant from ours to the *Monostroma leptodermum* Kjellm. Their plant has a long, slender, tubular stipe and the membrane is undulate and ruffled. It seems best to us, therefore, to consider that their plant is more likely to represent Kjellman's species and to place ours under the name bestowed upon it by Tilden.

4. **Monostroma areolatum** S. and G.

Plate 25 and Plate 26, fig. 2

Frond very delicate, lubricous, 20–35 cm. high, sessile, saccate when young, soon splitting and forming numerous, long, broadly ovate or obovate, undulate, plicate and much crisped lobes, pale green; membrane distinctly and finely areolate, 9–12μ thick; cells with rounded angles, 6–7μ diam., subspherical in cross section, grouped within each areole.

Growing on *Zostera* in quiet waters. Sitka, Alaska.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 281, pl. 30 and pl. 31, fig. 2.

This species of *Monostroma* is exceedingly beautiful and among the most delicate and flaccid of the genus. The frond remains saccate for a brief period only, attaining a height of but a millimeter or two. The sack then breaks and the membrane spreads out at once, early developing small lobes. Finally a few primary lobes are established and these develop numerous secondary lobes. The growth on the whole margin greatly exceeds that of the interior, which results in the production of a great number of folds, making the margin very much crisped. In the thickness of the frond and shape of the cells *M. areolatum* closely approximates *M. zostericola* Tilden. The cells of the latter are, however, more angular and more closely placed, and the frond is not divided into areolae. There is a marked difference in the size of these two species as well as in their method of development. *M. zostericola* is diminutive, remains saccate for some time, and then splits longitudinally, forming several lobes broadening outward. *M. areolatum* very closely resembles the genus *Prasiola* in the grouping of the cells as seen in surface view.

5. **Monostroma quaternarium** (Kuetz.) Desmaz.

Frond at first attached, soon becoming free, soft and delicate, irregularly lobed and folded, 20–23μ thick; cells rounded, when actively dividing set closely in threes and fours within the mother cell wall; in cross section semicircular or oval, 15–17μ high.

Floating in brackish and in fresh water. Washington to southern California.

Desmazières, Plantes Crypt. de France, 3 Sér., no. 603, 1859; Collins, Green Alg. N. A., 1909, p. 212; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 207. *Ulva quaternaria* Kuetzing, Tab. Phyc., vol. 6, 1856, p. 6, pl. 13, f. 2.

Monostroma quaternarium resembles *M. latissimum* in habit and habitat. Both are usually found in either brackish or fresh water and are not strictly marine. Both are usually found floating and are more or less indefinitely expanded. In *M. quaternarium* the cells are rounded, segregated in small groups of three or four in surface view, while in *M. latissimum* the cells are angular and closely placed, although at times appearing somewhat grouped. It is by no means a certain matter to place some specimens definitely in one species or the other. Such a case is presented by no. 218 of Farlow, Anderson and Eaton's Algae Americae Borealis Exsiccatae, collected near Santa Cruz, California, probably in an estuary.

6. **Monostroma latissimum** (Kuetz.) Wittr.

Frond at first attached, afterwards floating; thin and soft, glossy, of irregular shape, more or less plicate near the even or undulate margin; membrane 20–25μ thick, cells 4–6 cornered or roundish, closely set, without order or more or less distinctly in twos, threes and fours; in cross section vertically oval or nearly circular, 14–18μ high.

Attached to various objects in the lower littoral belt when young, but soon becoming free and floating in quiet waters, salt marshes, ditches, etc. Washington to central California.

Wittrock, Monostr., 1866, p. 33, pl. 1, f. 4; Collins, Green Alg. N. A., 1909, p. 211; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 207. *Ulva latissima* Kuetzing, Phyc. Gen., 1843, p. 296, pl. 20, f. 4.

As stated under the preceding species, *Monostroma latissimum* is usually to be found floating in shallow warmer waters, either brackish or fresh, seldom, if ever, in true marine localities. It is to be distinguished from the last (*M. quaternarium*) by the appearance of the cells both in surface view and in section as indicated in the descriptions.

The propriety of adopting the specific name *latissimum* for this species may be questioned. It seems to be the *Ulva latissima* of Kuetzing, but probably not the *Ulva latissima* of Linnaeus. We are not in a position to discuss this question, and simply follow later usage.

7. **Monostroma orbiculatum** Thur.

Frond membranaceous, attached by fibrils, or later free; soft and flaccid, sub-orbicular or irregular in outline, often radially plicate, with undulate margin, 30–40μ thick; cells angular, varying much in size and arrangement, often irregularly elongate, closely set, but with chromatophore not occupying the whole cell; in cross section vertically oval, 25–30μ high.

In brackish water attached to various objects in ditches of salt marshes. Central California.

Thuret, Note sur la Syn. Ulv., 1854, p. 388; Collins, Green Alg. N. A., 1909, p. 212; Wittrock, Monostr., 1866, p. 39, pl. 2, f. 6.

The present species resembles very closely the preceding and is, in fact, to be distinguished from it chiefly by its greater thickness. It may be a question as to whether it ought to be united with *Monostroma latissimum* or not. So far as our experience goes, however, the *M. latissimum* plants are definitely not over 25μ in thickness, and those of *M. orbiculatum* seldom less than 35μ. This seems to indicate sufficient difference for keeping them distinct.

8. **Monostroma fuscum** (Post. and Rupr.) Wittr.

Frond membranaceous, at first tubular, soon splitting, dull green, more or less lobed but not divided to the base; membrane 20–35μ thick; cells 4–6 angled, very closely set, in cross section quadrate, with only slightly rounded corners, occupying nearly the entire thickness of the frond.

On stones in the middle littoral belt, and floating in salt marshes. From Alaska to Puget Sound.

Wittrock, Monostr., 1866, p. 53, pl. 4, f. 13; Collins, Green Alg. N. A., 1909, p. 213; Saunders, Alg. Harriman Exp., 1901, p. 409; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 208. *Ulva fusca* Post. and Rupr., Illust. Alg., 1840, p. 21. *Ulva Lactuca* var. *rigida* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 209 (in part).

Monostroma fuscum var. **splendens** (Rupr.) Rosenv.

Frond deep green, glossy, 50–55μ thick, more deeply parted than in the other forms; cells similar to those of var. *Blyttii* or more rounded.

From Alaska to Vancouver Island.

Collins, Ulvaceae of N. A., 1903, p. 12, Green Alg. N. A., 1909, p. 213; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 209; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 911. *Monostroma splendens* Wittrock, Monostr., 1866, p. 50, pl. 3, f. 12; Setchell, Alg. Prib., 1899, p. 591. *Ulva splendens* Ruprecht, Tange Och., 1851, p. 410.

Monostroma fuscum var. **Blyttii** (Aresch.) Collins

Frond deep green, blackish in drying, 60–70μ thick; cells "palisade-form" in cross section.

Growing in tide pools and on pebbles in the sublittoral belt. Vancouver Island and Washington.

Collins, Ulvaceae of N. A., 1903, p. 12, Green Alg. N. A., 1909, p. 213. *Monostroma Blyttii* Wittrock, Monostr., 1866, p. 49, pl. 3, f. 11. *Ulva Blyttii* Aresch., *in* Fries, Sum. Veg. Scand., 1846, p. 129.

We are puzzled, when it comes to the discussion of *Monostroma fuscum*, whether to treat of it as a species or as a group of species. The typical *Monostroma fuscum* is comparatively thin (20–25μ according to Wittrock, 1866, p. 53), turning only a light brown on drying instead of black, and with cells quadrate or only slightly vertically elongated in cross section. The var. *splendens* is a thicker plant (49–53μ according to Wittrock, 1866, p. 51), turning black, adhering even less well to paper than the typical form and with cells vertically much elongated in cross section. The var. *Blyttii* differs from var. *splendens* chiefly in being thicker (65–72μ according to Wittrock, 1866, p. 49), but is otherwise essentially the same.

Rosenvinge (1893, p. 940, 1894, p. 146), relying upon the observations of Kleen (1874, p. 42), reduces the three species of Wittrock to two varieties of one, viz., var. *typica* and var. *splendens* of *Monostroma fuscum*. The arrangement of Rosenvinge has been generally followed and we feel that we can not do better than adopt the general opinion. We have, however, followed Collins (1909, p. 213) in retaining the varieties (or forms?) of *splendens* and *Blyttii* as well as the typical form. The typical form is perhaps a younger or less developed form and seems more distinct from both var. *splendens* and var. *Blyttii*, than they do from one another. We may expect any, or all, of the three forms anywhere along the coast from the Bering Sea to the Puget Sound region.

We have had no opportunity of observing the earlier stages of growth of any of the forms of this species, but Postels and Ruprecht

(1840, p. 21) describe the young specimens as provided with a short stipe, and Rosenvinge (1893, p. 942, f. 48, 1894, p. 148, f. 48) confirms this and adds figures of the young plants with stipes which remain tubular. No. 387 of Tilden's American Algae is, in our copy at least, a light colored plant, provided with a distinct tubular stipe about 3 cm. long and 3–4 mm. in diameter (in pressed specimen). This specimen previously referred by us to *Ulva Lactuca* var. *rigida* (cf. Setchell and Gardner, 1903, p. 210), has the structure, although not the exact color, of *Monostroma fuscum*.

Rosenvinge (1893, p. 942, f. 17 C, D, 1894, p. 147, f. 17 C, D) calls attention to the fact that each cell in this species contains two chromatophores, one at each end, and Jónsson (1904, p. 631) emphasizes this as characteristic of this species in distinction from all other species of *Monostroma*. Collins (1909, p. 25), however, finds only one chromatophore in fresh material of *M. fuscum* from Revere Beach, Massachusetts, and also calls attention to Wittrock's figure (1866, pl. 3, f. 11) which he says "shows a perfectly uniform chromatophore quite like that of the Revere Beach plant." We have seen what appear to be two distinct chromatophores in some of our specimens of varieties *splendens* and *Blyttii* where the cells are much elongated vertically, but have failed to find them in plants seemingly to be more of the type of the species.

19. **Enteromorpha** Link

Frond persistently tubular, usually slender, but often ample, simple, proliferous or branched, its wall consisting of a single layer of cells, commonly, but not always, arranged parenchymatously; all the cells of the membrane, except the very lowest, capable of producing zoospores or gametes, which are discharged through an opening in the outer cell wall.

Link, Epistola, 1820, p. 5.

The name *Enteromorpha* has been for so many years practically agreed upon among writers as the name for this genus that there is little need, perhaps, for anticipating any change. The only name which seems strictly and definitely to antedate it is that of *Tubularia* of Roussel (Flore du Calvados, ed. II, 1806) which is said to have been founded upon *Ulva intestinalis* (cf. Desvaux, Journ. Bot., 1813, p. 144). It is not possible for us to verify this reference at present and we follow the weight of authority in retaining *Enteromorpha* for the accepted generic name.

Enteromorpha is a genus of the Ulvales characterized by its tubular frond which is usually narrow, although much dilated at times in the case of certain varieties of *Enteromorpha intestinalis.* The species are usually branched, although some are normally simple or, at times, proliferous. This definition or characterization leads us to exclude *E. percursa* and its allies, *E. aureola* and its allies, and *E. Linza,* the two former being referred each to its own genus, viz., *Percursaria* and *Capsosiphon* respectively, and the last to the genus *Ulva.* The particular reasons for thus excluding from the genus *Enteromorpha* plants heretofore commonly referred to it will be given under the respective genera or species, while the general reason is that *Enteromorpha* thus reduced is more readily defined and apparently more natural. In addition to these changes, we have added to the genus *Enteromorpha* the species commonly known as *Monostroma groenlandicum,* because in detail of habit, at least, it is very much closer to *Enteromorpha* than to *Monostroma* and not so very diverse from some species of *Enteromorpha* even in structure.

The more characteristic species of *Enteromorpha* have the cells arranged closely set, and parenchymatous in appearance, but certain species show, at times, the cells separated considerably from one another by an intercellular jelly and this condition is normal in *E. groenlandica,* which, for this reason, usually has been placed under the genus *Monostroma.* The cells are arranged in longitudinal rows in many species. Some species show a continuance of this arrangement even on into the adult condition, while others soon lose it. The chromatophore generally fills the cell as seen in surface view, but in a few species it occupies only a small portion of the surface of the cell.

Much is to be determined in *Enteromorpha,* as is also the case in *Monostroma* and *Ulva,* from the thickness, shape and proportions of the cells, and the disposition of the enclosing intercellular substance in cross sections of the membrane. Such sections also show the degree of compression of the frond and whether the walls are completely separated from one another or not.

In branching there is great variation, not only in the genus, but within many of the species. It has seemed best, nevertheless, to consider the method of branching as one of the chief characters in separating the species.

The species of *Enteromorpha* present difficulties which have not yet been entirely overcome. The habit is of importance, but varies considerably either under environmental changes or with age in such

a fashion as to be insufficient in itself for diagnosis. The anatomical characters, on the other hand, seem to be more reliable, but, of themselves, present difficulties and seeming abnormalities or departure from type. Very few of the older species have been carefully described anew from the type specimens, so that uncertainty holds in many cases as to the exact application of specific names. Different writers, also, differ decidedly as to their views of specific limits and groupings of forms, so that a student of this group finds much variance of opinion, and consequent resulting confusion.

We have followed the accounts of Collins (1903 and 1909, p. 195 *et seq.*) very largely, but with due attention to the revision of J. G. Agardh (1883, p. 115 *et seq.*) and the critical remarks of Reinbold (1889, p. 113 *et seq.*), Börgesen (1902, p. 487 *et seq.*), Jónsson (1903, p. 343 *et seq.*) and Kylin (1907, p. 4 *et seq.*). Very considerable assistance has been obtained also from the earlier monograph of the group by Ahlner (1877) especially as interpreted by J. G. Agardh. Study has been made of the living plant so far as possible, and dried specimens have been boiled in water before examination to restore cell outlines and chromatophores. This method of preparation has given very satisfactory results, the dried specimens swelling up and assuming a form and structure closely approximating that of the living material. Even the chromatophores are fairly well restored to size, shape and position.

The species of *Enteromorpha* inhabit brackish water and strictly fresh water as well as strictly salt water and that which passes for the same species may be found in all three. The amount of salinity of the water may, seemingly at least, have very different effects particularly upon the branching and the thickness of the membrane. Careful cultures, however, are needed to establish this fact clearly and convincingly. It may be stated that the culture of various species and forms of the different species of *Enteromorpha* is very necessary before a definite basis for many of the distinctions now employed may be assured.

The species of *Enteromorpha* are probably more nearly "cosmopolitan" than those of any other genus of marine algae, although the term cosmopolitan can not, in all probability, be used in the strictest sense, even in connection with them. The ranges of the different species along our western coast of North America are more extensive than those of the species of most other genera. This is to be explained, we think, by the fact that the species of *Enteromorpha*

are of rapid development and early maturity, so that their effective season of growth may be short, and on the basis of their being, for the most part, essentially tropical or subtropical species. Such warm water species of rapid development may extend into zones of colder surface waters by growing in the upper littoral belt where they may take advantage of the temperatures of the air, or by inhabiting shallow pools or lagoons the temperature of which is raised by the influence of the atmosphere and sunlight.

Key to the Species

1. Cells separated, often widely from one another, seldom parenchymatous, unbranched ..... 1. **E. groenlandica** (p. 248)
1. Cells usually distinctly parenchymatous, simple or more usually branched 2
2. Cells not arranged in longitudinal rows except, at times, in very youngest parts 3
2. Cells arranged in longitudinal rows in the greater portion of the frond 7
3. Frond with more or less plentiful branches 4
3. Frond simple or with few proliferations 5
3. Frond beset with mostly simple, stout, spinelike branchlets ..... 6. **E. acanthophora** (p. 254)
4. Frond flattened, branching from the margins ..... 2a. **E. micrococca forma subsalsa** (p. 249)
4. Frond tubular compressed, branches contracted at the base, becoming broader above ..... 4. **E. compressa** (p. 251)
5. Cells 10–16μ diam., fronds usually inflated and constricted, often of large size ..... 5. **E. intestinalis** (p. 252)
5. Cells 4–8μ diam., fronds usually short 6
6. Membrane 8–10μ thick, cells 5–7μ diam ..... 3. **E. minima** (p. 250)
6. Membrane 15–20μ thick, cells 4–5μ diam ..... 2. **E. micrococca** (p. 249)
7. Frond simple, inflated and flexuous ..... 8. **E. flexuosa** (p. 255)
7. Frond simple or with occasional proliferations, not inflated 8
7. Frond regularly branched 10
8. Frond narrowly linear, strongly compressed ..... 10. **E. marginata** (p. 257)
8. Frond filiform, capillary or tubular 9
9. Frond capillary of few longitudinal rows of cells ..... 12. **E. torta** (p. 258)
9. Frond coarse, plainly tubular, of numerous longitudinal rows of cells ..... 9. **E. tubulosa** (p. 256)
10. Frond beset with numerous thorn-like branches ..... 11. **E. salina var. polyclados** (p. 257)
10. Frond proliferous, branches similar to main axes .... 7. **E. prolifera** (p. 254)
10. Branches of successive orders, tapering from base to apex 11
11. Chromatophores filling the cell 12
11. Chromatophores not filling the cell 13
12. Ultimate ramuli and branch tips of a single series of cells ..... 13. **E. crinita** (p. 258)
12. Ultimate ramuli and branch tips of more than one series of cells ..... 14. **E. erecta** (p. 259)
13. Ultimate ramuli and branch tips of a single series of cells .. 15. **E. plumosa** (p. 259)
13. Ultimate ramuli and branch tips of more than one series of cells ..... 16. **E. clathrata** (p. 260)

1. **Enteromorpha groenlandica** (J. Ag.) S. and G.

Frond filiform, tubular, cylindrical, up to 15 cm. long, from a very slender base expanding to 1 mm. diameter; apex broken only at exit of spores; cells in the lower part loosely arranged in twos and fours, roundish angular; cells in the upper part more evenly distributed, more or less loosely set; in cross section the membrane 25–35μ thick; the cells radially elongate, 2–4 times as long as broad; in the younger parts the central cavity filled with a gelatinous substance which disappears as the plant becomes older; spores or gametes forming first at the summit of the frond, and developing successively in lower cells.

On small boulders in the middle littoral belt. Alaska (Bay of Unalaska and Kukak Bay).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 280. *Monostroma groenlandicum* J. Agardh, Till Alg. Syst., part III, 1883, p. 107, pl. 3, f. 80–83; Collins, Green Alg. N. A., 1909, p. 208; Saunders, Alg. Harriman Exp., 1901, p. 410; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 208.

Enteromorpha groenlandica has always been puzzling as to its proper placing. While technically it may seem to belong to the genus *Monostroma*, under which it was originally described, more properly than to any other genus of the Ulvaceae, yet its slender, filiform habit certainly more closely resembles that of some species of *Enteromorpha*. From *Enteromorpha*, however, it differs in not having its cells set sufficiently closely together to be parenchymatous in appearance. It is at first solid, becoming hollow only late, but never rupturing longitudinally and opening out into a membrane as do the characteristic species of *Monostroma*. Certain species of *Enteromorpha* show a tendency towards abundance of intercellular jelly at times, while certain species of *Monostroma* are parenchymatous. It seems best to us, therefore, to transfer this species to *Enteromorpha*.

The plants of the North Pacific Ocean, as Collins (1909, p. 209) states, have decidedly smaller cells than those of the North Atlantic, measuring 8–10μ in diameter, as against 12–16μ as seen superficially. It seems, therefore, to constitute a different form.

The species is a summer plant of the Upper Boreal Zone, invading the Lower Boreal and North Temperate Zones only as a short-lived plant of the springtime when the waters are colder than in the summer. This intrusion happens, so far as we have evidence, only on the eastern

coasts of North America where the Massachusetts coast experiences a much colder winter and spring season than do western coasts of North America of the same zones. On the Pacific Coast, so far as our knowledge goes, the species is confined to the Bering Sea and adjacent portions of the Alaskan Peninsula where the summer temperature of the surface waters seldom, if ever, rises above 10° C.

2. **Enteromorpha micrococca** Kuetz.

Frond 1–5 cm. long, 1–5 mm. wide, tubular or compressed, simple or slightly proliferous at times, much curled and twisted; cells angular, 4–5μ diam., in no definite order; membrane 15–20μ thick, with distinct inner hyaline layer.

Growing in the upper littoral belt, on rocks and on woodwork. From Alaska (Dutch Harbor) to Mexico (*fide* Collins, *loc. cit.*).

Kuetzing, Tab. Phyc., vol. 6, 1856, p. 11, pl. 30, f. 2; Collins, Green Alg. N. A., 1909, p. 204; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 211; Saunders, Alg. Harriman Exp., 1901, p. 411.

2a. **Enteromorpha micrococca** forma **subsalsa** Kjellm.

Plate 16, fig. 1

Frond compressed, much contorted, with numerous, patent or uncinate, shorter or longer branches from the margin, the latter again branched, all broad at the base and tapering to a point.

Growing on stones in the littoral belt. Alaska (Skagway) to Washington (Puget Sound).

Kjellman, Alg. Arctic Sea, 1883, p. 292, pl. 31, f. 1–3; Collins, Green Alg. N. A., 1909, p. 204, Mar. Alg. Vancouver Is., 1913, p. 102; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 211; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1068 (fresh water). *Enteromorpha minima* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 213 (in part); Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 912.

Enteromorpha micrococca is, in typical form, a low plant forming a layer on rocks and woodwork high up in the littoral belt. It is to be distinguished by its small cells, not arranged in longitudinal rows, and its thicker membrane which is reinforced by a hyaline layer on the inside. In its ordinary marine habitat, it seldom shows any

tendency towards branching, but plants agreeing with it in anatomical characters, but growing in brackish or fresh waters, branch abundantly from the margins, the branches tapering at the tips and being usually curved. Such plants are referred under the forma *subsalsa.* This variety occurs at times, especially in fresh water, up to 10 cm. or more long. The var. *bullosa* which Collins distributed under no. 1067 of the Phycotheca Boreali-Americana seems to differ decidedly from *Enteromorpha micrococca* in the size and shape of the cells and approaches more nearly *E. intestinalis* in structure. This variety is known, thus far, only from fresh water (San Leandro, California) and does not strictly come under our consideration.

3. **Enteromorpha minima** Naeg.

Frond 1–10 cm. long, 1–5 mm. broad, simple or slightly proliferous, dilated or collapsing, soft and delicate, cells angular, 5–7μ diam., arranged in no definite order; membrane 8–10μ thick, equally thickened on both surfaces.

Growing on stones and on wood in uppermost littoral belt.

From Alaska (Unalaska) to Mexico.

Naegeli, *in* Kuetzing, Sp. Alg., 1849, p. 482, Tab. Phyc., vol. 6, 1856, p. 16, pl. 43, f. i-m; Collins, Green Alg. N. A., 1909, p. 201, Mar. Alg. Vancouver Is., 1913, p. 102; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 213.

Enteromorpha minima resembles *E. compressa* but is, in normal form, less likely to show any branching, is more commonly dilated, and of softer and more delicate texture. The cells are also slightly smaller in surface view. From *E. micrococca,* this species is to be distinguished by the larger cells and thinner membrane which is seldom noticeably thickened on the inside, although Kuetzing (1856, pl. 43, f. m) so represents it. *Enteromorpha minima* resembles *E. micrococca* rather than *E. compressa* in size, but is found in typical form up to 10 cm. high. In fresh water forms attributed to this species we find plants up to 20 cm. long and sometimes with the cells decidedly separated from one another as in *Monostroma.* In a form from dripping rocks above high water mark on San Juan Island, Washington, distributed under no. 912 of the Phycotheca Boreali-Americana, the plants are large and the cells small, with the membrane thickened on the inside. This seems to approach very closely to *E. micrococca.*

4. **Enteromorpha compressa** (L.) Grev.

Plate 14, figs. 7, 8; plate 16, fig. 3

Frond tubular, more or less compressed, sometimes constricted, varying much in dimensions; branches usually simple, cylindrical or expanding above, in either case narrowed at the base, similar in appearance to the main axis; cells in no definite order; membrane rather thin.

Growing in the middle and lower littoral belts. From Alaska (Bering Sea) to Mexico (Magdalena Bay).

Greville, Alg. Brit., 1830, p. 180, pl. 18; Collins, Green Alg. N. A., 1909, p. 201, Mar. Alg. Vancouver Is., 1913, p. 101; Setchell and Gardner, Alg. N. W. Amer., 1903, p. 213. *Enteromorpha prolifera* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 221 (as to no. 5687 only). *Enteromorpha fascia* Postels and Ruprecht, Illust. Alg., 1840, p. 21; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 211; Collins, Green Alg. N. A., 1909, p. 204. *Ulva compressa* Linnaeus, Fl. Suec., Ed. II, 1755, p. 433.

We have followed the opinion of J. G. Agardh (1883, p. 137) as to the nature and limits of *Enteromorpha compressa*. The habit of typical plants is well illustrated in our figures (plate 14, figs. 7, 8, and plate 16, fig. 3). The branches may arise from the very base or at different heights along the axis. They are uniformly constricted at the base and usually expanded to a rounded tip. The broader portions of the frond are almost always flattened and the layers may be very imperfectly separated. Sections of such imperfectly tubular fronds often bear a striking resemblance to those of *Ulva Linza*, especially when separation is present only on the margins as may happen in spots.

The differences between *Enteromorpha compressa* and *E. minima* have already been noticed under the latter species. The resemblance to narrow forms of *Ulva Linza* is sometimes puzzling, especially in unbranched specimens (var. *subsimplex* J. Ag.) or in specimens only slightly branched.

We refer under *Enteromorpha compressa* the *E. fascia* of Postels and Ruprecht (1840, p. 21) since the habit (plate 16, fig. 3) is the same and the size and shape of the cells, both in surface view and in cross section, are identical. The cell contents, however, in the type specimens of *E. fascia* are disorganized in such a way as to seem almost as if there were groups of small cells within the larger ones. The color of the type specimens is also somewhat brownish. We ascribe this as well as the peculiar appearance of the cell contents to

some abnormal state or unusual treatment of the specimens. The type specimens of *E. fascia,* as they were found in the Imperial Academy of St. Petersburg in 1903, were labelled as having been collected by the Luetke Expedition in Kamtschatka.

Of specimens distributed from our coast we find in our copy of the American Algae that Tilden's no. 265, under the name of *E. compressa* var. *complanata* is *E. crinita* and no. 264, under the name of *E. compressa* var. *subsimplex* is *E. plumosa.*

Most of the specimens available to us for examination are close to the typical form of *E. compressa* but certain plants collected by one of us (Gardner) at Coos Bay, Oregon, seem referable rather to var. *subsimplex* J. Ag. (1883, p. 137).

5. **Enteromorpha intestinalis** (L.) Link

Frond simple or having at the base a few branches similar to the main frond, or occasionally a few proliferations above; length varying from a few centimeters to several meters; diameter from 1–10 cm.; at first attached by a short cylindrical stipe, but often later detached and floating; cylindrical or expanding above, more or less inflated, often much crisped and contorted, and irregularly and strongly constricted; cells 10–16μ diam., in no regular order; thickness of membrane varying from 50μ below to 20μ above, generally thickened on the inside; cells in cross section from 12–30μ.

Common in its various forms from Alaska (Kukak Bay) to Mexico (La Paz).

Link, Epistola, 1820, p. 5; J. Agardh, Till Alg. Syst., part 3, 1883, p. 131; Collins, Green Alg. N. A., 1909, p. 204, Mar. Alg. Vancouver Is., 1913, p. 102; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 212; Saunders, Alg. Harriman Exp., 1901, p. 411. *Ulva intestinalis* Linnaeus, Flo. Suec., Ed. II, 1755, p. 418.

Howe (1911, p. 490) has referred doubtfully a plant from La Paz, Mexico, to this species.

The following forms have been detected on our coast:

Forma **cylindracea** J. Ag.

Frond long and slender, of uniform diameter; usually floating unattached.

J. Agardh, Till Alg. Syst., part 3, 1883, p. 131; Collins, Green Alg. N. A., 1909, p. 205; Mar. Alg. Vancouver Is., 1913, p. 102; Saunders, Alg. Harriman Exp., 1901, p. 411; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 212.

Forma **maxima** J. Ag.

Frond large, up to 4 cm. diam., inflated and bullate, producing small, scattered branches.

J. Agardh, Till Alg. Syst., part 3, 1883, p. 132; Collins, Green Alg. N. A., 1909, p. 205, Mar. Alg. Vancouver Is., 1913, p. 102; Saunders, Alg. Harriman Exp., 1901, p. 411; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 212; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1182.

Forma **clavata** J. Ag.

Frond always attached, filiform below, enlarging more or less abruptly upwards, open at the upper end, 1–5 cm. wide, 1–5 dm. long.

J. Agardh, Till Alg. Syst., part 3, 1883, p. 131; Collins, Green Alg. N. A., 1909, p. 205, Mar. Alg. Vancouver Is., 1913, p. 102. *Enteromorpha intestinalis* f. *genuina* Hauck, Meeresalg., 1885, p. 426; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 212; Tilden, Amer. Alg. (Exsicc.), no. 263.

There appears to be no authenticated type specimen of the *Ulva intestinalis* of Linnaeus in existence (cf. Jackson, B. D., 1912, p. 147), so that we must follow general tradition as to the nature of this species. As generally agreed upon, it possesses a tubular frond usually inflated, of varying length and diameter, often twisted or constricted, usually branched from a slender base, occasionally slightly proliferous above, and with the rather large, angular or slightly elongated cells not arranged in longitudinal rows, at least not in the adult frond. Under this conception are arranged many and seemingly diverse forms both as to shape and size. The most slender plants of f. *cylindracea,* e.g., may not be much over 1 or 2 mm. in greatest diameter, while the largest of f. *maxima,* on the contrary, may be 10 cm. through. In regard to amount of inflation, smoothness or rugosity of surface, constriction or lack of it, and even of thickness or thinness of the membrane itself, there is much difference between specimens seemingly correctly referred to *Enteromorpha intestinalis.* What these very diverse forms indicate needs cultural experimentation to demonstrate. At present, we assume an identical genetic constitution for all and hold the varying environmental conditions responsible for transformations of form. This method is very unsatisfactory, but it is the best that can be done at present. Even with the wide range of characters we have given to the species, we have, nevertheless, followed the more

restricted point of view rather than the more ample conception. The form names appended to the species, as given above, are simply for the purpose of giving some idea of the amplitude of variation of the species even as most narrowly delimited.

6. **Enteromorpha acanthophora** Kuetz.

Frond more or less proliferously branched, the branches usually constricted at the base, beset with numerous short, spinelike ramuli, with somewhat narrowed base and acute tip; cells 11–13μ diam., angular, showing no longitudinal arrangement except indistinctly at the tips of the ramuli and in the spinelike branchlets.

Guaymas, Mexico.

Kuetzing, Sp. Alg., 1849, p. 479, Tab. Phyc., vol. 6, 1856, pl. 34, f. 1; Collins, Green Alg. N. A., 1909, p. 200 (in part).

The figure and description of Kuetzing (1849, p. 479 and 1856, pl. 34, f. 1) provide our chief knowledge of this species, the type specimens of which are from New Zealand. We have not seen the type but have studied New Zealand specimens which seem to belong here. We are encouraged to refer to this species, although doubtfully, specimens collected by T. S. Brandegee at Guaymas, Mexico, which have a general resemblance to *Enteromorpha intestinalis,* but which are beset with short, spinelike branches. We do not think that no. 515 of the Phycotheca Boreali-Americana, a plant of fresh water, is properly to be referred to *E. acanthophora.* Its membrane is too thin (about 13μ, instead of 30–45μ) and its cells (4–5μ diam., instead of 10–13μ) and cross section, as well as its branching more closely, resemble those of *E. micrococca* f. *subsalsa,* although not strictly in agreement with them.

7. **Enteromorpha prolifera** (Muell.) J. Ag.

Frond up to several meters long and 2 cm. diam., tubular or compressed, with more or less abundant proliferous branches, which are usually simple, but sometimes also proliferous; branches varying much in length and diameter; cells 10–12μ in diameter, in the younger parts always arranged in longitudinal series, which become somewhat less distinct in the older parts; membrane 15–18μ thick, not much exceeding the dimensions of the cells in cross section.

Growing on sticks and stones, sometimes floating, in quiet waters and sheltered bays. From Alaska (Sitka) to central California.

J. Agardh, Till Alg., Syst., part 3, 1883, p. 129, pl. 4, f. 103, 104; Collins, Green Alg. N. A., 1909, p. 202; Saunders, Alg. Harriman Exp., 1901, p. 411; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 211; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 913; Tilden, Amer. Alg. (Exsicc.), no. 385. *Ulva prolifera* Mueller, *in* Fl. Dan., vol. 5, fasc. 13, 1778, pl. 763, f. 1.

We must necessarily adopt the idea of J. G. Agardh as to the nature and limits of *Enteromorpha prolifera,* but neither he, nor any other writer, as far as we know, has examined the type. The illustration in the Flora Danica (*loc. cit.*) simply shows the habit and might represent either this species or some form of *E. intestinalis.* The fronds of forms of *Enteromorpha prolifera* resemble those of forms of *E. intestinalis* in habit, but are generally more proliferous. They vary from those of *E. intestinalis* in having slightly smaller cells, but differ particularly in having the cells arranged in longitudinal rows in the lower portions, at least, and in the branches. In size and shape, as well as in extent and variety of branching, there is great variation.

Enteromorpha prolifera also resembles *E. compressa* at times, when the tube is collapsed, but may generally be distinguished from that species by the longitudinal arrangement of cells in the branches. It is closely related to *E. tubulosa* and *E. flexuosa,* but in these species the cells are more regularly and uniformly arranged in longitudinal rows than they are in *E. prolifera. Enteromorpha tubulosa* is more or less branched and the membrane is not thickened within, while *E. flexuosa* is typically unbranched and with the membrane inwardly thickened. *E. prolifera* may be simple at first, but is usually branched later and is destitute of a thickening of the inner surface of the membrane.

8. **Enteromorpha flexuosa** (Wulf.) J. Ag.

Frond cylindrical, tubular, simple, tapering to a filiform stipe below, inflated above, flexuous and intestine-like; cells 8–12μ long, 6–8μ wide, roundish polygonal, in longitudinal series; membrane somewhat thickened on the inside; chromatophore filling the thick-walled cell.

Growing on rocks and on other plants. Santa Barbara, California.

J. Agardh, Till Alg. Syst., part 3, 1883, p. 126; Collins, Green Alg. N. A., 1909, p. 203. *Conferva flexuosa* Wulf., *in* Roth, Cat. Bot., II, 1800, p. 188.

J. G. Agardh (*loc. cit.*) is responsible for separating this species from among the forms previously referred to *E. intestinalis*. No recent examination of the type is reported. As taken by J. G. Agardh it seems to be a simple, more or less slender tube with the cells arranged in longitudinal rows and with the membrane somewhat thickened on the inside. It is generally regarded as being an inhabitant of warmer waters (cf. J. G. Agardh, 1883, p. 127, and Collins, 1909, p. 203). We have not seen it on our coast, but J. G. Agardh credits to this species a specimen collected by Mrs. Bingham at Santa Barbara, California.

9. **Enteromorpha tubulosa** Kuetz.

Plate 14, figs. 4, 5

Frond simple or with short proliferations, usually near the base, but with occasional longer proliferations some distance above the base, tubular and nearly cylindrical throughout, or enlarging upward from a delicate cylindrical stipe and becoming compressed above; cells squarish, 11–15μ diam., arranged in longitudinal series throughout, less distinctly so in the upper mature parts; membrane 15–24μ diam., walls equally thickened on both sides, with cells squarish or slightly elongated radially, chromatophore filling the outer end of the cell.

Growing attached to rocks in the lower littoral belt, or floating in intertwined masses in pools in salt marshes. Central California.

Kuetzing, Tab. Phyc., 1856, p. 11, pl. 32, f. 2; Ahlner, *Enteromorpha*, 1877, p. 49, f. 9a, 9b. *Enteromorpha prolifera* var. *tubulosa* Collins, Green Alg. N. A., 1909, p. 203; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 462 (Key West, Florida).

Kuetzing's figure of *Enteromorpha tubulosa* represents a simple plant, but J. G. Agardh (1883, p. 128) states that it branches. The main frond is tubular and slender, of nearly uniform diameter throughout. Our specimens are all branched more or less, but usually from near the base. The membrane may be thickened on both sides or not at all. There has been some difference of opinion among writers as to the proper relationship of this plant, but it seems best to us to retain it as an independent species.

10. **Enteromorpha marginata** J. Ag.

Frond filiform, compressed, simple or with a few proliferous branches; cells 4–8μ diam., squarish, arranged in longitudinal series, very distinctly in the two or three rows at each side, less so in the middle portion.

Vancouver Island (Departure Bay) to California.

J. G. Agardh, Algae Med., 1842, p. 16; Collins, Green Alg. N. A., 1909, p. 202, Mar. Alg. Vancouver Is., 1913, p. 102.

Enteromorpha marginata is a very slender plant, usually of salt springs or salt marshes. It is most commonly simple and of low stature. It is credited to our coast by Collins (*loc. cit.*), but we have had no specimens for examination.

11. **Enteromorpha salina** var. **polyclados** Kuetz.

Frond small, tubular, with occasional branches similar to the main filaments, all beset with short, spinelike, patent ramuli ending in a single series of cells and varying from few in some specimens to very numerous in others; cells squarish, arranged in longitudinal series.

Floating in tangled masses in salt-water ponds. Central California.

Kuetzing, Phyc. Germ., 1845, p. 248; Collins, Green Alg. N. A., 1909, p. 202. *Enteromorpha polyclados* Kuetzing, Tab. Phyc., vol. 6, 1856, pl. 36, II.

We have encountered floating in sun-heated pools in the salt marshes or in the artificially warmed water of the Key Route Pool, but all in the neighborhoods of Oakland and Alameda, California, what seems to be the above listed variety of *Enteromorpha salina*. Our plants are slender, with few or no main branches, cells squarish and in distinct longitudinal rows, and beset with branchlets consisting of one or two longitudinal rows of cells throughout. The main portions of the broader fronds sometimes show as many as twenty cells across, but there are only four to eight to be seen in the more usual slender fronds. We have referred all our plants to the variety but some show details of structure exactly corresponding to those of the species (cf. Kuetzing, 1856, pl. 36, f. I).

12. **Enteromorpha torta** (Mert.) Reinb.

Frond small, 1–3 cm. long, filiform, simple or with occasional proliferations consisting of two rows of cells; cells rectangular, always in longitudinal series throughout the filaments and more or less in cross series; chromatophore thin, covering the greater part of the cell.

Growing attached to rocks, in shallow pools in the upper littoral belt. San Diego, California. December.

Reinbold, Rev. Juergens' Alg. aquat., 1893, p. 201 (p. 14, Repr.). *Conferva torta* Mertens, msc., *in* Juergens, Dec. 13, no. 6.

We are inclined to refer here a slender plant from San Diego, California, collected by one of us (Gardner, no. 3574) although it shows no branches in any of the samples we have examined. It agrees fairly closely with the unbranched plants in the specimen distributed by Reinbold under no. 624 of the Phykotheka Universalis. Our plant may possibly be a short, capillary form of *E. tubulosa,* with cells more regularly arranged in longitudinal rows.

13. **Enteromorpha crinita** (Roth) J. Ag.

Frond filiform, cylindrical or compressed, much and repeatedly branched, the branches tapering towards the tips, the smallest, as well as the tips of the larger, usually of a single series of quite short cells; cells almost always in longitudinal series, often rounded, quite or nearly filled by the chromatophore.

Growing on wood or floating in the littoral belt. From Alaska (Valdes) to California (San Diego).

J. G. Agardh, Till Alg. Syst., part 3, 1883, p. 144; Collins, Green Alg. N. A., 1909, p. 199, Mar. Alg. Vancouver Is., 1913, p. 101; Saunders, Alg. Harriman Exp., 1901, p. 412; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 214; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 965. *Enteromorpha compressa* f, *complanata* Tilden, Amer. Alg. (Exsicc.), no. 265 (not of J. G. Agardh). *Enteromorpha prolifera* Tilden, Amer. Alg. (Exsicc.), no. 385 (not of J. G. Agardh). *Conferva crinita* Roth, Cat. Bot., 1797, I, p. 162, pl. 1, f. 3.

Enteromorpha crinita is usually a slender, much branched plant, with tapering branches of several orders, the tips of the branches ending in a single series of cells. The chromatophore, as seen in surface view, seems to fill the cell and thereby distinguishes this species from

the very similar *E. plumosa.* This interpretation of *E. crinita* is that of J. G. Agardh (*loc. cit.*) who founds his opinion upon a specimen determined by Roth.

14. **Enteromorpha erecta** (Lyng.) J. Ag.

Frond filiform, with numerous long, usually erect branches, more slender than the main filament; the ultimate ramuli of varying length, polysiphonous, the cells being symmetrically arranged in successive segments, similar to those of *Polysiphonia;* cells in the main axes and branches in longitudinal and usually in transverse series; chromatophore filling the cell.

Rare on the Pacific Coast, known only from Vancouver Island (Comox) and California (Santa Rosa Island).

J. G. Agardh, Till Alg. Syst., part 3, 1883, p. 152; Collins, Green Alg. N. A., 1909, p. 200. *Scytosiphon erectus* Lyngbye, Hydr. Dan., 1819, p. 65, pl. 15 C.

Enteromorpha erecta is to be distinguished from *E. crinita* by having the tips of the branches polysiphonous instead of monosiphonous (ending in a single row of cells). It is to be distinguished from *E. plumosa* in the same way as well as by having the chromatophores filling the cells. By the latter character it is also to be distinguished from *E. clathrata.*

J. G. Agardh (1883, p. 152) states that his *Enteromorpha erecta* is the same as a specimen sent out by Dillwyn under the name of *Conferva paradoxa* Dillwyn, but, since the description of Dillwyn seems to him to have been made from another plant and Dillwyn's figure ill drawn, he does not adopt Dillwyn's specific name. It is impossible for us to do more than call attention to this statement, but it seems to us very probable that Dillwyn's specific name may be the proper one to be used for this plant.

15. **Enteromorpha plumosa** Kuetz.

Frond slender, filiform or later compressed, repeatedly branched, branches tapering from the base and ending in a single series of cells; cells in longitudinal series, less distinctly so in the older parts of the frond, 8–10μ wide in the monosiphonous parts; chromatophore not filling the cell.

Floating in slightly brackish water. Washington (Puget Sound) and California (San Francisco).

Kuetzing, Phyc. Gen., 1843, p. 300, pl. 20, f. 1; Collins, Green Alg. N. A., 1909, p. 198. *Enteromorpha compressa* f. *sub-simplex* Tilden, Amer. Alg. (Exsicc.), no. 264 (not of J. G. Agardh).

In *Enteromorpha plumosa,* we find the counterpart of *E. crinita,* as mentioned under that species, except that the chromatophore, as seen from surface view, does not fill the cell. This is a character sometimes difficult to determine in dried specimens and may possibly be variable under different conditions of metabolism. Thus far it has been generally accepted since its suggestion by J. G. Agardh (1882, p. 151), but cultural experimentation to determine its constancy is desirable. J. G. Agardh (*loc. cit.*) prefers *Enteromorpha Hopkirkii* McCalla (cf. Harvey, 1849, p. 215, 1851(?), pl. 263) for reasons which we can not comprehend. Kuetzing's figure (1843, pl. 20, f. 1) seems to us definite and exact.

16. **Enteromorpha clathrata** (Roth) Grev.

Frond filiform, cylindrical or compressed, much branched in all directions, the branches tapering from base to summit, but not ending in a single series of cells; cells rectangular, usually longer than broad, always in longitudinal series, the chromatophore noticeably smaller than the cell.

Forming large, floating masses in warm, quiet waters. Alaska (Sitka) to central California.

Greville, Alg. Brit., 1830, p. 181; Collins, Green Alg. N. A., 1909, p. 199, Mar. Alg. Vancouver Is., 1913, p. 101. *Conferva clathrata* Roth, Cat. Bot., 1806, III, p. 175.

This species is the counterpart of *Enteromorpha erecta,* but with the chromatophore not filing the cell. *Enteromorpha clathrata* and *E. erecta* bear a similar relation to one another to that borne by *E. crinita* to *E. plumosa.* The identification of Roth's species seems to rest with Mertens, who is followed by J. G. Agardh (1883, p. 153) and, in turn, by all recent writers.

20. **Ulva** L.

Frond membranaceous, flat, consisting of two layers of cells usually closely applied throughout, but in some species separating at the base and margins; zoospores or gametes formed from any cell except those of the thickened, or hollow, stipe and escaping through an opening in the surface of the frond.

Linnaeus, Gen. Plant., 1737, p. 326, Sp. Plant., vol. 2, 1753, p. 1163 (in part).

The name *Ulva* goes back into classical Latin and was used to designate some marsh plant. It was adopted by some of the botanists to designate the expanded or gelatinous algae of any color. Linnaeus used it, at first, for a combination of species now referred to *Ulva, Monostroma(?), Enteromorpha, Porphyra, Botrydium* and *Nostoc,* later extending it to other expanded or non-*Fucus* species of all four groups of algae. If we are to follow some weighty authorities, we may be compelled to believe that Linnaeus included in his original list no one of the species generally referred to *Ulva.* If *Ulva Lactuca* L. is really a *Monostroma;* if *Ulva latissima* L. (at least of the Species Plantarum) was founded on a portion of the blade of *Laminaria saccharina;* and if we refer *Ulva Linza* to the genus *Enteromorpha,* then there is no species of *Ulva,* in the sense in which it is now used, left in the original list of Linnaeus.

As genera came to be more strictly delimited, *Ulva* came more and more to be reserved for membranous or tubular forms and ultimately for those belonging to the Chlorophyceae. Finally, in 1854, Thuret gave it its final description and content by the separation of the species of *Monostroma.* J. G. Agardh (1883, p. 160), although differing from Thuret as to some details, followed Thuret's segregations, and since that time the general concept has been the same for all writers. The genus *Ulva,* therefore, may be defined as including those species of the Chlorophyceae which have a parietal chromatophore and with the cells arranged, in large part at least, in a two-layered membrane. We have arranged our plants under *Ulva* in accordance with this idea, including even those like *Ulva Linza* which, in habit, seem to belong to *Ulva* and the greater portion of whose fronds remain as two layers closely applied to one another.

The species of *Ulva* are generally regarded as being not readily separable from one another, and the universal tendency has been to divide the genus into a few widely distributed and variable species. There is, however, great need of careful and extensive monographic work on this genus. In our attempt to distinguish the species and forms of our own coast, we have come to the conclusion that the plants fall into certain groups, fairly readily to be distinguished from one another. We have been able, also, to refer these narrower groups of forms to described species with plausible certainty. We trust that we may be able to stimulate, at least, careful scrutiny of these species and

to refer observations as to the behavior of the plants referred to them. Cultural studies are needed and, although possibly difficult, may, even for certain more readily grown forms, yield results of extended application.

From our own experience, we feel convinced that general habit and size do not, as a rule, vary within extensive limits in the adults of the same species, while the details of cell structure are fairly uniform for any particular part of an adult plant within the species. Both habit and cell structure are sufficiently variable among the species, however, to afford intelligible diagnostic characters.

Key to the Species

1. Frond lanceolate with tubular stipe....1. **U. Linza** (p. 262)
1. Frond variously shaped, stipe when present, solid.... 2
2. Cells square, or nearly so, in cross section.... 3
2. Cells distinctly vertically elongated in cross section.... 6
3. Frond seldom over 2 cm. high....2. **U. californica** (p. 264)
3. Frond usually over 2 cm. high.... 4
4. Frond narrowly lanceolate....3. **U. angusta** (p. 264)
4. Frond broad in proportion to length.... 5
5. Frond attached, orbicular or ovate, often deeply split....4. **U. Lactuca** (p. 265)
5. Frond usually soon free, ample and exapnded....5. **U. latissima** (p. 266)
6. Frond broad in proportion to height.... 7
6. Frond narrow in proportion to height or with long, narrow laciniae.... 9
7. Frond apparently regularly and abundantly perforated....6. **U. fenestrata** (p. 267)
7. Frond not perforate or occasionally showing a few irregular holes.... 8
8. Frond ample, usually with deep ruffled margins....7. **U. expansa** (p. 268)
8. Frond moderate, deeply lobed, with slightly ruffled or plane margins....8. **U. lobata** (p. 268)
8. Frond short ovate, plane, usually deeply split....9. **U. rigida** (p. 269)
9. Frond long, usually simple, more or less ruffled....10. **U. stenophylla** (p. 271)
9. Frond very short, simple, plane....11. **U. vexata** (p. 271)
9. Frond deeply divided into long, narrow, crisped laciniae....10
10. Laciniae borne on a short, broad, basal portion, not dentate below....12. **U. dactylifera** (p. 272)
10. Laciniae split to the very base, dentate below....13. **U. taeniata** (p. 273)

1. **Ulva Linza** L.

Plate 12, figs. 1–4

Frond lanceolate or linear-lanceolate, simple, 1–5 dm. long, 1–20 cm. broad; stipe longer or shorter, hollow; upper part of the frond flat, the two layers of cells completely united or remaining free along the whole or part of the margins, which are plane or more or less undulate; membrane 25–70μ thick; cells usually vertically elongated in section, up to twice as high as broad.

Growing on wood, rocks, and on other algae, in the lower littoral belt. Alaska (Orca) to Mexico (La Paz).

Linnaeus, Sp. Plant., vol. 2, 1753, p. 1163. *Enteromorpha Linza* J. Agardh, Till Alg. Syst., part 3, 1883, p. 134, pl. 4, f. 110–112; Collins, Green Alg. N. A., 1909, p. 206, Mar. Alg. Vancouver Is., 1913, p. 102; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 212; Howe, Phyc. studies, V, 1911, p. 490; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 967 b; Tilden, Amer. Alg. (Exsicc.), no. 384. *"Ulva Lactuca* forma *genuina"* Tilden, Amer. Alg. (Exsicc.), no. 260 (not of Hauck).

The figure of Dillenius (1741, pl. 9, f. 6) quoted by Linnaeus (1753, p. 1163) under *Ulva Linza,* seems sufficiently characteristic to distinguish this species. We find, however, that it becomes necessary to include under the name a very considerable variety of forms. Some of these forms are very narrow, while others are comparatively broad. In some, the hollow stipe gradually expands into the blade, while in others the passage from one to the other is extremely abrupt and the blade is broad, even slightly cordate, at the base. Many plants of *Ulva Linza* are short (a few cm. long) while some are very long (up to 1 M. or more). The margins, in turn, may be perfectly flat and plane while, in others, they are decidedly, even conspicuously, undulate or deeply ruffled. The hollow stipe and greater or less extent of hollow margin, however, distinguish all forms of *Ulva Linza* from any other species of *Ulva,* and the considerable expanse of two-layered blade distinguishes them from any species of *Enteromorpha.*

While *Ulva Linza* is an *Enteromorpha* at the base and on the lower margins, it is decidedly an *Ulva* so far as the expanded blade is concerned. It might, with justice, be placed in either genus, but since the habit in general is that of an *Ulva* and the greater portion of any plant of the species is ulvoid, it seems to us that the novice, at least, is more likely to arrange it with *Ulva* than with *Enteromorpha.* We have decided, therefore, to restore it to the genus *Ulva.*

It has been customary since the account of J. G. Agardh (1883, p. 134) to distinguish two forms of *Ulva Linza,* the one (f. *lanceolata*) with the margins plane or undulate and the other (f. *crispata*) with the margins crisped. Since all degrees of ruffling or absence of it occur in plants seemingly to be referred to the species, it does not seem practicable to distinguish sharply between them.

2. **Ulva californica** Wille

Frond 1.5–2 cm. long, up to 1.5 cm. wide, triangular or reniform with wavy edge, sometimes with proliferations of a few cells each, passing abruptly into a slender, filiform stipe; cells of the stipe, which on the inner side form rhizoidal prolongations, are in cross section about quadrate; membrane 30–35μ thick; the cells in the upper part of the frond are rather irregularly polygonal with rounded corners; no noticeable arrangement in longitudinal series.

Growing in profusion on rocks near high-tide line. California (region about San Diego).

Wille, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 611; Collins, Green Alg. N. A., 1909, p. 215.

Our knowledge of *Ulva californica* is derived from the type and other specimens collected by Mrs. M. S. Snyder at La Jolla, near San Diego, California. It seems to be a very small species with a comparatively long stipe and having the cells small and nearly isodiametric. In this combination of characters it seems amply distinct from all other species of the genus.

3. **Ulva angusta** S. and G.

Plate 22, and plate 26, fig. 1

Frond simple or very rarely lobed, lanceolate to oblanceolate, 8–15 cm. long, 0.5–1.5 cm. wide, 35–45μ thick (occasionally about 53μ), tapering either gradually or abruptly at the base to a delicate, solid stipe with discoidal holdfast, color of fronds pale green, margins varying from almost plane to very much crisped; cells in surface view 3- 6-sided, with rounded angles, 5–12μ diam., in section, quadrate to one and a half times longer than broad, with rounded angles; chromatophore filling the outer half of the cell.

Growing in shallow pools along high-tide level. California (region of San Francisco).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 283, pl. 27, and pl. 31, fig. 1.

We find at several places along the coast of central California, a rather short and narrow *Ulva* which does not seem to belong to any of the hitherto described species. We have felt compelled, therefore, to give it a name. It resembles the *Phycoseris lapathifolia* of Kuetzing (1856, pl. 25) but is shorter and narrower. It also resembles,

even more closely, Kuetzing's figure of *Phycoseris Linza* (1856, pl. 16, f. I), but is a smaller plant than that also. The short, flattened stipe is solid. The narrow blade varies from plane to undulate or even crisply ruffled on the margins. The cells are oblong or rounded in section, each provided with more or less of a distinct wall. Although we have only recently become acquainted with it, this seems to be a vernal species. It has been observed in fertile condition in April.

4. **Ulva Lactuca** L.

Fronds short, usually broader than long, attached by a disk from a broad or attenuate base, generally deeply and irregularly split, light to dark green in color, delicate in texture, margins plane or ruffled; membrane 35–50μ thick (usually about 40μ); cells in section nearly square with rounded angles or slightly elongated, seldom one and one half times higher than broad even in fertile condition.

Growing attached at first in the upper littoral belt. From Alaska (St. Michael) to Mexico (Gulf of California).

Linnaeus, Sp. Plant., vol. 2, 1753, p. 1163 (in part?); Thuret, Note Syn. *Ulva Lactuca*, 1854, p. 24; Thuret and Bornet, Études Phyc., 1878, p. 5, pl. 2, 3; Collins, Green Alg. N. A., 1909, p. 214, f. 75 (in part). *Ulva Lactuca* f. *rigida* Tilden, Amer. Alg. (Exsicc.), no. 386 (not of Le Jolis).

Ulva Lactuca, as described by Linnaeus, is not so definitely delimited as to be intelligible, so that different views have been held as to its nature. A specimen exists in the Linnaean Herbarium (cf. Benjamin Daydon Jackson, 1912, p. 147) labeled in the handwriting of the younger Linnaeus. We have no knowledge of this specimen and have seen no account as to its examination. It is certain that a number of the earlier writers agree in referring here a plant which, tubular at first, finally splits. On this account, the *Ulva Lactuca* L. is a *Monostroma* or perhaps included both a *Monostroma* and an *Ulva*. With all due respect to these authorities, it has seemed best to us to follow a considerable number of recent writers who have followed the opinion of Thuret (1854, p. 24) as to the real nature of *Ulva Lactuca*. The plant described by Thuret and Bornet in their Études Phycologiques (1878, p. 5, pl. 2, 3) is the one we have in mind in the reference of the specimens of our coast. This species has a frond broadly lanceolate, attenuated to a very short stipe below, broadened and more or less deeply and coarsely lobed above. The membrane is about

40μ thick at about the middle and the cells in section are circular or oblong and but very slightly elongated vertically in section even when fertile. The substance of the membrane is soft and slightly lubricous. Taken in this narrower sense, we find specimens both from our own coasts and those of Europe in agreement. This leads us to include this species as defined above, but not in the broad sense, as including *Ulva rigida* Ag., *U. latissima* L., and other species as has been the customary usage of recent writers. On this account, it is impossible, at present, to give an extended synonymy under the species. Vickers (1908, pl. 1) has figured what seems to be a tropical form of true *Ulva Lactuca* and Hauck has distributed a specimen from Trieste (cf. Hauck and Richter, Phyk. Univ., no. 17).

5. **Ulva latissima** L.

Frond ample, broader than long, usually soon free and expanded, often reaching a considerable size, yellowish green; membrane 35–40μ thick; cells, in section, nearly square or elongated horizontally.

On mud flats and in quiet bays sometimes completely covering extensive areas. Alaska (Juneau).

Linnaeus, Sp. Plant., vol. 2, 1753, p. 1163 (in part?). *Ulva Lactuca* var. *latissima* De Candolle, Flore Française, ed. 3, vol. 2, 1805, p. 9; Collins, Green Alg. N. A., 1909, p. 215 (in part), Mar. Alg. Vancouver Is., 1913, p. 103 (in part?); Setchell and Gardner, Alg. N.W. Amer., 1903, p. 210 (in part). *Ulva Lactuca myriotrema* Saunders, Alg. Harriman Exp., 1901, p. 410 (not of Le Jolis).

Ulva latissima of the Species Plantarum (Linnaeus, 1753, p. 1163) may or may not be the same as that of the Flora Suecica (Linnaeus, 1755, p. 433) and the questions as to whether either of these is the *U. latissima* of other authors, whose conceptions also have varied, are not to be solved by us. We infer that the specimen of *Ulva latissima* in the Linnaean Herbarium is not labeled either in Linnaeus' own hand or those of any known amanuensis (cf. Benjamin Daydon Jackson, 1912, p. 147). It is apparently (cf. Turner, Fuci, vol. 3, 1811, p. 72 and English Botany, vol. 22, 1806, text under pl. 1551) a fragment of the blade of *Laminaria saccharina*. The plant upon which the name given in the Species Plantarum is based was collected by Linnaeus on his trip into West Gothland, Sweden (Linnaeus, 1753, p. 1163, "iter w. gotl. 160").

We have followed the conception of J. G. Agardh (1883, pp. 164–166) as to the proper nature of the Linnaean species and have referred here those ample floating forms, with thin membranes, and cells which are cubical or horizontally elongated in section. We find very few such plants on our coast, their place as ample, expanded, floating membranes being taken by *U. expansa.* One specimen, however, collected near Douglas, Alaska, by Mr. Eldred Jenne seems clearly to belong here, and other specimens may be expected in quiet waters. The specimen from Douglas, Alaska, agrees fairly well with no. LXXVI of the Phycotheca Boreali-Americana, but is somewhat thinner.

6. **Ulva fenestrata** P. and R.

Frond ample, usually soon free and expanded, yellowish green, completely, and more or less uniformly, perforated with larger and smaller round or elongated openings with undulate edges, margins often wavy; membrane up to 60μ thick; cells in section nearly square or slightly vertically elongated (about 20μ high by 16μ broad in thicker sections); chromatophore cucullate at outer end of cell.

Growing on rocks in the lower littoral and upper sublittoral belts. Alaska (Sitka) to Puget Sound, Washington.

Postels and Ruprecht, Ill. Alg., 1840, p. 21, pl. 37.

The question as to the origin of the perforations found apparently regularly in some species of *Ulva* and occurring more or less sporadically in many or all species, has not, as yet, been at all carefully investigated. Greville (1830, p. 172) speaks of the frond of *Ulva latissima* as being "frequently much perforated by marine animals." On the other hand, J. G. Agardh (1882, p. 171) in speaking of *U. rigida* and its forms, states that the holes found in this species, as well as in *U. reticulata* Forsk., are not the work of animals, but due to inequalities of growth. We find holes frequently in considerable numbers in various of the *Ulvae,* as well as of the *Porphyrae,* of our coast and we feel certain that in many cases, at least, they are the work of mollusks, but we also find specimens of a large species of *Ulva,* which seems likely to be *U. fenestrata,* in which the holes are so numerous and so regular, and so constantly found that we are inclined to believe them to be the results of growth of the uninjured frond. We have, consequently, referred them here, although with much doubt, since other than as to perforations, they agree well with specimens of *Ulva expansa.* Some of the specimens in our possession are as long as 4 meters and up to 13 decimeters wide. As to details of perforation, our specimens agree with those figured by Postels and Ruprecht.

7. **Ulva expansa** (Setchell) S. and G.

Frond ample, pale green, orbicular or broadly elongated, margin deeply ruffled; frond 60–70μ thick in the middle, 38–45μ on the margins; cells, in section, vertically elongated in the middle of the frond (up to 28–30μ long, 10–12μ wide), nearly square in the margins.

Growing on rocks in the lower littoral belt. Washington (Puget Sound) to Mexico (La Paz).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 284. *Ulva fasciata* f. *expansa* Setchell, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. LXXVII; Collins, Green Alg. N. A., 1909, p. 216.

We find along the coast of central California a broad species of *Ulva,* often also long, something like *Ulva latissima* in appearance, yet of a more vivid green color, thicker in the center of the frond and with distinct, broad, ruffled margins. The cells of the thicker center of the frond are distinctly palisade-like in section, while on the thinner margins they are nearly square. A younger specimen of this plant was distributed by one of us as *Ulva fasciata* f. *expansa* (Phyc. Bor.-Amer., no. LXXVII), but it has seemed, on further study, to belong neither to *Ulva fasciata* Delile nor to the *Ulva fasciata* f. *taeniata* also distributed by one of us (Phyc. Bor.-Amer., no. 809), but described later in this account as *Ulva taeniata.* We have therefore described it (Setchell and Gardner, 1920, p. 284) as an independent species under the name of *Ulva expansa.*

Ulva expansa, so far as we have observed it, remains attached only for a short time. It soon becomes free and floats or drifts, increasing in size, becoming at times at least 3 meters long and varying in width from 18 cm. to 75 cm. In form and structure it differs from *Ulva latissima* and from all the other species of *Ulva* of our coasts. It comes nearest to *Ulva fenestrata* as we have described that species, but is little, if at all, perforate. Plants of what appears to be the same species have been found in the Puget Sound region and Howe (1911, p. 490) is inclined to credit here some from La Paz, Mexico.

8. **Ulva lobata** (Kuetz.) S. and G.

Frond dark green, of moderate size (up to about 30 or more cm. long and 10–15 cm. broad), more or less deeply lobed or divided, attenuate to a cuneate, crisped, often more or less twisted base,

margins plane or slightly undulate; membrane 45–90μ thick, thicker in the center and thinner near the margins; cells elongated vertically, up to two and one half times as high as broad in the thicker central portion, nearly square at the margins.

On rocks in the lower littoral belt. Central California (San Francisco) to southern California (Pacific Beach).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 284. *Phycoseris lobata* Kuetzing, Spec. Alg., 1849, p. 477, Tab. Phyc., vol. 6, 1856, p. 10, pl. 27. *Ulva fasciata* f. *lobata* Setchell, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 863; Collins, Green Alg. N. A., 1909, p. 216.

Among the *Ulvae* of the Californian coast is one of moderate size (up to 30 cm. or more long and to 15 or more cm. broad) which is distinct in general appearance. It is attenuate at the crisped base, broadening above and usually lobed or divided into several broad divisions. The margins are either plane or slightly undulate. Like *U. expansa* it is thicker in the center with palisade-like cells (in section) and thinner on the margins where the cells are nearly square (in section). It bears a striking likeness in every way to Kuetzing's figure (1856, pl. 27) of his *Phycoseris lobata* from Chili. We have, therefore, referred it to his species with some doubt.

Ulva lobata belongs to the same group of species as *U. expansa* but is generally firmer in substance, slightly thicker, never reaches a great size, and is less deeply or conspicuously ruffled. It is well represented by the specimens distributed in the Phycotheca Boreali-Americana (under no. 863).

The most typical plants are those of the central Californian coast (San Francisco to Monterey). We have referred here also one plant from southern California, but with some doubt.

9. **Ulva rigida** Ag.

Frond low, at first lanceolate or ovate-lanceolate, firm and stiff, with distinct stipe, later broader and irregularly deeply divided; membrane 60–110μ thick, varying with age and position in the frond; cells, in section, vertically elongated, one and one half to three times as high as broad.

Growing attached to rocks and other algae, upper littoral belt. Alaska (Uyak Bay) to Mexico (La Paz).

Agardh, Sp., vol. 1, part 2, 1822, p. 410. *Ulva Lactuca* var. *rigida* Le Jolis, Alg. Mar. Cherb., 1863, p. 38; Collins, Green Alg. N. A., 1909, p. 215 (in part), Mar. Alg. Vancouver Is., 1913, p. 103 (in part); Saunders, Alg. Harriman Exp., 1901, p. 410 (in part); Setchell and Gardner, Alg. N.W. Amer., 1903, p. 209 (in part); Howe, Phyc. Studies, V, 1911, p. 490.

Ulva rigida must needs be carefully studied and redescribed from the type specimen before any exact knowledge is possible as to the nature of the species. Agardh (1822, p. 410) describes it as from 3 or 4 up to about 9 inches long, split to the base into curved and crisp laciniae. J. G. Agardh (1883, p. 168) describes it as having cells vertically elongated in section to 2 to 3 times their width. He, however, refers as typical the figure of *Ulva Lactuca* of Thuret and Bornet's Études Phycologiques (1878, pl. 2, e). Yendo (1916, p. 244) says that J. G. Agardh has taken a broader view of the species than did C. Agardh. Yendo refers to *U. rigida,* in the sense of its founder, the *Ulva conglobata* Kjellm. and its f. *densa* as well as the *Ulva fasciata* f. *caespitosa* Setchell (Phyc. Bor.-Amer., no. 809). Yendo does not, however, state definitely just the characters of the type of *U. rigida* Ag.

The *Ulva conglobata* Kjellm. seems to us to agree well with the *U. fasciata* f. *caespitosa* Setchell (Phyc. Bor.-Amer., no. 809, nom. nud.), both as to habit and as to structure. The cells in each are only slightly, if at all, elongated vertically in section. We are inclined to refer both of these plants to *Ulva Lactuca* as small forms. The *Ulva conglobata* f. *densa,* however, seems different in its structure. Judging by Kjellman's figure (1897*a*, pl. 3, f. 15), the cells are decidedly vertically elongated in cross section, and this form probably, therefore, belongs to *U. rigida* in the sense of J. G. Agardh.

We have, in the light of what has been written, considered the *Ulva rigida* to be a low plant, rigid, deeply divided, rather thick and with cells vertically elongated in section. The membrane usually shows a rather thick hyaline layer under each surface, and another between the layers of cells. We have found that certain of our specimens conform to these characters and are to be distinguished by them from any other species of *Ulva.*

10. **Ulva stenophylla** S. and G.

Plate 21, fig. 2, and plate 24

Frond simple, linear-lanceolate, tapering abruptly at the base to a very short, flattened, cuneate stipe, 5–8 dm. high, 5–10 cm. wide, plane in the middle with undulate margins; membrane 60–110μ thick; cells squarish in surface view, 14–20μ diam., 1.5–2 times as long as the diameter in section, chromatophore a thin parietal layer, covering a part or the whole of the cells; pyrenoids absent.

Growing on rocks in the lower littoral belt. Central California.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 282, pl. 26, fig. 2, and plate 29.

The plants described under this name are quite distinct from the other species of *Ulva* in shape, texture and anatomical details. They are dark green, tough and harsh to the touch. The usually simple, long, lanceolate shape serves to distinguish them from other species at a glance.

11. **Ulva vexata** S. and G.

Plate 17, figs. 4–7

Frond small, unbranched, rigid, linear to oblanceolate or spatulate, plane or slightly undulate, more or less bullate with cuneate base and small, solid stipe, 1–3 cm. long, 3–10 mm. wide, dark green, black on drying; membrane 45–55μ, up to 100μ thick, cells vertically elongated, 11–15μ, up to 18μ long, 3.5–5μ wide, with thick walls and very blunt angles in surface view; chromatophore filling the cell, pyrenoids absent.

Growing on rocks along high-tide level. In the vicinity of San Francisco, California.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 282, pl. 22, figs. 4–7. *Ulva californica* Reed, Two Ascomycetous Fungi, etc., 1902, p. 149 (not of Wille).

Ulva vexata has been observed only in the vicinity of San Francisco, as mentioned above, where it grows in considerable profusion. It seems quite probable that it may be much more widely distributed both north and south of San Francisco. It might be suspected of being a malformation due to the parasite always found more or less infesting it, but the size and proportions of the cells of the less parasitized portions seem to mark it as a distinct species.

12. **Ulva dactylifera** S. and G.

Plate 21, fig. 1

Frond sessile or with a very short stipe; basal portion orbicular or reniform, much crisped, 2–4 cm. high, giving rise from the upper margin to 1–6 lanceolate, simple or occasionally branched lobes or laciniae with plane midrib and much crisped margins, 5–15 cm. high, 0.5–1.5 cm. wide; membrane of basal portion 50μ thick at the margin, up to 100μ thick in the middle, with cells 16–20μ diam. in the surface view, quadrate to 2 times as long as wide in section, membrane of the laciniae 40–50μ thick on margin, up to 190μ thick in the middle, with cells 12–16μ diam. in surface view, quadrate to 5 times as long as wide in section; chromatophore filling the outer half of the cell.

On exposed rocks, uppermost littoral belt. Southern California to Mexico (San Roque?).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 285, pl. 26, fig. 1.

We have along the Californian coast two species related to *Ulva fasciata,* neither of which seems to be exactly like the Mediterranean species. Both are characterized by long, narrow fronds or laciniae, much thicker along the middle and with thinner, very much crisped margins. One of these, *Ulva dactylifera,* possesses a comparatively broad, though short, undivided basal portion from which arise the several narrow, elongated, crisped laciniae. Neither the basal portion nor the laciniae show distinctly toothed margins. The other species, *Ulva taeniata,* is either simple, long, slender, plane and dentate below, but with crisped margins above, or divided to the very disk itself into two or three such divisions. The "midrib" portions differ slightly in thickness in the two species and the cells of the "midribs" differ in proportions.

Ulva dactylifera has been distributed under no. 221 b (sub "*Ulva fasciata*") of the Phycotheca Boreali-Americana. Unfortunately the plants under this number are not uniform. We have examined no. 221 b in two copies. In one, the plant is certainly, although not typically, *U. dactylifera.* In the other it seems rather to be a form of *Ulva Lactuca.*

Ulva dactylifera is nearest to *U. fasciata* f. *costata* Howe (1914, p. 20, pls. 1, 2, f. 10–23), but differs as to the basal portion, thickness, and possibly also in proportions of cells. It differs from *U. fasciata*

Delile, so far as descriptions and figures indicate, in branching, in ruffling, and probably in thickness. It is a very much thinner plant than *U. nematoidea* Bory, judging from the dimensions given by Bornet (1892, p. 36 or 196).

13. **Ulva teniata** (Setchell) S. and G.

Plate 23

Frond elongated, up to 1 or 2 M. long, simple or split to the very base into long, narrow segments, plane below and coarsely dentate, densely crisped and ruffled on the margins above, with a plane, thicker midrib; membrane up to 140μ thick as to the "midrib" and down to 40μ thick on the margins; cells of the "midrib" vertically elongated in section up to two and one half times as high as broad, but becoming nearly square towards the margins.

On rocks in lowermost littoral or upper sublittoral belts. Central California (Tomales Bay to Monterey).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 286, pl. 28. *Ulva fasciata* f. *taeniata* Setchell, *in* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 862; Collins, Green Alg. N. A., 1909, p. 216.

Ulva taeniata has been found thus far on the coasts of central California only, while *U. dactylifera* has been found only on those of southern California. The differences between the two species have been enumerated under the latter species. From *U. fasciata* f. *costata* Howe, it differs particularly in its basal portion. *Ulva fasciata* Delile seems to be a species nearly if not absolutely plane, while *U. taeniata* is always crisply ruffled. No. 862 of the Phycotheca Boreali-Americana represents this species very well.

21. **Percursaria** Bory

Frond slender, filamentous at first, of a single series of cells, later becoming two longitudinal rows of cells placed symmetrically side by side throughout, or only in portions, of the filament; cells rectangular, with thick walls and a single chromatophore.

Bory, Dict. class. d'hist. nat., vol. 13, 1828*a*, p. 206. *Tetranema* Areschoug, Phyc. Scand. Mar., Sect. II, 1850, p. 418 (not *Tetranema* Bentham, 1843). *Diplonema* Kjellman, Norra Ishaf. Algfl., 1883*a*, p. 371 (not *Diplonema* Don, 1838, nor *Diplonema* De Notaris, 1846).

The genus *Percursaria* was founded by Bory in 1828 to receive the *Ulva percursa* Ag. Bonnemaison founded a genus of the same name in 1822 (p. 178) quoted as *"Percussaria"* by Leman (Dict. d'hist. nat., vol. 38, 1825, p. 425) which is a mixture of filamentous Myxophyceae with no type designated. It certainly seems to us that the *Ulva percursa* Ag. is a very distinct plant belonging in no other genera of the Ulvaceae as properly limited. We follow Rosenvinge and others in keeping it separate. It is, in reality, a very narrow membrane, seldom, if ever, more than two cells wide. It may possibly be looked upon as a very primitive form among the Ulvaceae.

Percursaria percursa (Ag.) Rosenv.

Plate 14, fig. 6

Frond several cm. long, flexuous and contorted, generally irregularly and frequently contracted to a single row of cells or expanded to a double row; cells 10–15μ wide and from once to twice as long.

In entangled masses with other filamentous algae in upper tide pools, in ditches in salt marshes and similar places where the water is warmed by the sun. From Alaska (Bay of Unalaska) to central California (San Francisco Bay).

Rosenvinge, Groenl. Havalg., 1893, p. 963, Alg. Mar. du Groenl., 1894, p. 160. *Conferva percursa* Agardh, Syn. Alg. Scand., 1817, p. 87. *Tetranema percursum* Areschoug, Phyc. Scand. Mar., Sect. II, 1850, p. 418. *Diplonema percursum* Kjellman, Norra Ishafv. Algfl., 1883*a*, p. 371, Alg. Arct. Sea, 1883, p. 302. *Enteromorpha percursa* Setchell and Gardner, Alg. N.W. Amer., 1903, p. 214; Collins, Green Alg. N. A., 1909, p. 197; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 968.

This interesting plant, so unlike a member of the Ulvaceae in general appearance, seldom occurs pure, but is generally mixed with those species of *Cladophora, Enteromorpha* and filamentous Myxophyceae which delight in the same conditions of life. It is readily to be told from its associates by the very symmetrically placed double row of cells.

Order 5. SCHIZOGONIALES west

Thallus filamentous or membranaceous, deep green; cells dividing in one, two or three planes strictly at right angles to one another, chromatophores axile; multiplication by proliferation (or gemmation) of the thallus, by akinetes, or by the latter directly forming aplanospores; zoospores and gametes unknown.

West, G. S., Brit. Freshw. Algae, 1904, p. 98.

This order differs from that of the Ulvales by the cells possessing axile instead of parietal chromatophores, and by the absence of zoospores and gametes. Otherwise, the members in general appearance closely resemble those of the Ulvales. The order comprises one family and one to four genera according to the views of different writers. The species are largely inhabitants of fresh water or of damp, usually foul, earth, but a few are marine.

family 10. SCHIZOGONIACEAE chodat

The characteristics are the same as those of the order.

Chodat, Alg. vertes de la Suisse, 1902, p. 341.

In choosing the name of this family, all depends upon whether *Schizogonium* is to be retained as a distinct genus. Until more definite cultural work has been carried through, it seems best to us to retain *Schizogonium* distinct from *Prasiola* and, consequently, we have adopted Chodat's name in preference to the Prasiolaceae of West (1904) or the Blatosporaceae of Wille (1909).

Key to the Genera

1. Adult frond an expanded membrane.....22. **Prasiola** (p. 275)
1. Adult frond a solid filament.....23. **Gayella** (p. 279)

22. **Prasiola** Menegh.

Frond membranaceous, monostromatic, attached by short filiform prolongations, by the edge of the membrane, or by a thickened stipe; cells with stellate, axile chromatophore and one pyrenoid, dividing to form groups of fours, these groups forming similar larger groups, the spaces between the groups of various orders constituting narrower or wider spaces, running in definite directions through the frond; asexual reproduction, (1) by the breaking off of smaller portions

of the frond which attach themselves and grow independently; (2) by akinetes, formed from individual cells assuming thick walls, and developing either directly into a filament or a membrane, or indirectly by aplanospores, several in each akinete; (3) by aplanospores, formed 4–512 in a cell, by walls in 2 or 3 directions; sexual reproduction and zoospores unknown.

Meneghini, Cenni Organo. e Fisiol., 1838, p. 36. Tribe 4, *Ulvae* (*Prasiola*) Agardh, Sp. Alg., 1822, p. 416.

The genus *Prasiola* was first described as a tribe of the genus *Ulva* by C. A. Agardh (*loc. cit.*) and later raised by Meneghini (*loc. cit.*) to independence. There are three monographs of *Prasiola*, viz., by Jessen (1848), by Lagerstedt (1869) and by Imhäuser (1889). De-Toni (1899, p. 140 *et seq.*) enumerates twelve species, of which three are reckoned doubtful. Three of the remaining nine species are marine and the rest terrestrial or inhabitants of fresh waters. Several additional species have been described, one of which is a marine species from our own coast.

We find four species along our coast which have claims to be considered marine and there are probably as many more terrestrial or fresh-water species known from western North America. Much more study of seasonal forms and developmental stages is necessary, and the number of aplanospores produced by the aplanosporangia needs more careful determination. The formation of the "aplanospores" resembles very closely the formation of the male cells or sperms in *Porphyra* and may, according as the mother cell separates completely or incompletely into two or four at the first two divisions, be a certain number or four times that number as Hus has shown takes place in antheridial formation in *Porphyra* (cf. Hus, 1902, p. 190). Complete aplanospore formation has been followed in only one species, viz., *Prasiola delicata*.

Key to the Species

1. Cells in distinct areoles, intercellular lines more or less distinct 2
1. Cells in indistinct areoles, intercellular lines absent or indistinct 3
   2. Frond slender, long, stipitate, stipe of a single row of cells towards the base ..... 1. **P. calophylla** (p. 277)
   2. Frond broad, when stipitate, stipe broad, of more than one row of cells towards the base ..... 2. **P. borealis** (p. 277)
3. Membrane up to 17–20μ thick ..... 3. **P. delicata** (p. 278)
3. Membrane up to 40–45μ thick ..... 4. **P. meridionalis** (p. 278)

1. **Prasiola calophylla** (Carmich.) Menegh.

Fronds linear to narrowly cuneate, with truncate apex, many from the same holdfast, seldom over 1 cm. long, 1 mm. wide; cells near the base in a single series, about 10μ long by 3–5μ broad; farther up in two rows, the number increasing towards the upper part of the frond or as the frond grows older; the series of cells and the intercellular lines nearly parallel throughout; cells near the apex of the frond about 3–5μ diam., square; thickness of frond about 15μ; cells 8–10μ high in cross section.

Growing in brackish water. Washington (Whidbey Island).

Meneghini, Cenni sull' Organografia, 1836, p. 36; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 215; Collins, Green Alg. N. A., 1909, p. 219. *Bangia calophylla* Carmichael, *in* Greville, Scottish Crypt. Flora, vol. 4, 1826, p. 220.

This species has been observed only once in anything like a marine locality. One of us (Gardner) found it at the head of Penns Cove on Whidbey Island, growing within reach of pure salt water. It is a small, slender species and is easily recognized by having a long tapering stipe ending below in a single row of cells. It is probably not to be expected at all frequently in marine localities.

2. **Prasiola borealis** Reed

Plate 10, figs. 1–3

Fronds cuneate to obovate, stipitate or sessile, margin crenulate, crisped or entire, soft membranaceous, 33–45μ thick, 5–10 mm. high, in tufts of several from one holdfast; cells in distinct tetrads, areolar arrangement manifest; cells 4–9μ diam., seen superficially; in cross section oblong or palisade-form, 11–14μ high; aplanospores probably numerous within each aplanosporangium, in groups of 8.

Growing on rocks just above high water mark. Alaska.

Reed, Two new ascomycetous Fungi, 1902, p. 160, pl. 15, f. 7; Collins, Green Alg. N. A., 1909, p. 220; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 215; Trelease, The Fungi of Alaska, 1904, p. 34, pl. 7, f. 1, 5.

Prasiola borealis has been found only on the Alaskan coast (Unalaska, Kadiak and Baranof Island) and always infested with a fungus (*Guignardia alaskana* Reed), thus resembling the *Mastodia tessellata* Hook. and Harv. (cf. J. D. Hooker, 1847, p. 499, pl. 194, II)

whose algal portion was later referred to *Prasiola tessellata* by Kuetzing (1849, p. 473). *P. borealis* differs from *P. tessellata* at least in habit and in being less regularly areolate. *Prasiola borealis* also resembles *P. furfuracea* (Mert.) Menegh. except in that its cells are larger, the membrane thicker, and the areolae and intercellular lines more distinct (cf. also Reed, *loc. cit.*, p. 156).

A similar composite to those of *Prasiola borealis* Reed with *Guignardia alaskana* Reed and *Prasiola tessellata* Kuetz. with *Guignardia Prasiolae* (Winter) Reed is the *Dermatomeris georgica* Reinsch (1890, p. 425, pl. 19, f. 1–6), which has not been, so far as we are aware, examined carefully with regard to its two components.

3. **Prasiola delicata** S. and G.

Plate 17, fig. 3; plate 19, fig. 8; plate 20, fig. 1

Frond 1–1.5 mm. high, broad and shortly stipitate, expanding directly and abruptly to broadly oblong or cordate, margins crisped and inrolled, dark bluish green; membrane 17–20μ thick, cells not grouped into distinct areolae and not separated by intercellular lines; akinetes not seen; aplanospores up to 512 from a single cell ($8 \times 8 \times 8$) but often only 128; cells palisade-like and 10–12μ in vertical diameter, in section twice or more as high as broad.

Growing at or near the upper tide mark on rocky islets. Sitka, Alaska.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 291, pl. 22, fig 3; pl. 24, fig. 8; pl. 25, fig. 1.

Prasiola delicata has a decidedly thinner membrane than any other of our marine species, shows little areolation, and has a large number of aplanospores formed within a single aplanosporangium. These characters seem to indicate its just claim to be considered a distinct species. It is known to us, as yet, from a single collection, although in considerable quantity.

4. **Prasiola meridionalis** S. and G.

Plate 20, fig. 2

Frond up to 7 mm. high, with short and broad stipe, soon expanded into a broad, cordate, rosulate or cucullate blade, dirty green; cells neither arranged in distinct areolae nor separated by intercellular lines; membrane 40–45μ thick, section showing cells 14–18μ high

and 7–8μ wide with broad, hyaline margins (up to 13μ thick); akinetes scattered, large thick walled; aplanospores probably 128–512 ($4\times4\times8$ or $8\times8\times8$) from a single aplanosporangium.

On exposed rocks or rocky islets above the high water mark but exposed to the force of the waves. Washington (Friday Harbor and Neah Bay) to central California (entrance to Tomales Bay).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 291, pl. 25, fig. 2.

The specimens taken as the type of this species were collected by one of us (Gardner, no. 3824) at Neah Bay, Washington. We are also inclined to refer here specimens collected on "Minnesota Reef" at Friday Harbor, Washington, and at the entrance to Tomales Bay, California. In both of the last two localities, the species is associated with *Gayella constricta*. Cultures, however, definitely indicate the independence of the two plants of one another.

Prasiola meridionalis comes near to *P. borealis* Reed, but the frond of the latter is areolate and with more or less distinct intercellular lines. *P. borealis,* so far as found, is infested with a fungus (*Guignardia alaskana* Reed) while none of the three collections of *P. meridionalis* shows any trace of such a parasite.

23. **Gayella** Rosenv.

Frond filiform, simple or very slightly branched, at first of a single series of cells, later dividing longitudinally into many series, but always remaining filiform, not flat; cell structure as in *Prasiola.*

Rosenvinge, Groenl. Havalg., 1893, p. 936.

Gayella may be a genus of doubtful autonomy, but the cylindrical rather than flattened character of its fronds seems to mark it off distinctly from *Prasiola.* The behavior of *Gayella constricta* in cultures, in retaining its characters and never showing a *Prasiola*-stage, induces us to retain the genus. Our experience of both species of our coast does not confirm that of Börgesen (1902, p. 482 *et seq.*) and we, therefore, feel unwilling to consider *G. polyrhiza* as a subspecies of *Prasiola crispa.* Certainly our *G. constricta* shows no distinctly transitional forms to the *Prasiola* found associated with it.

Key to the Species

1. Up to 175μ diam. above, frequently constricted.....2. **G. constricta** (p. 280)
1. Up to 70μ diam. above, without constrictions.....1. **G. polyrhiza** (p. 280)

1. **Gayella polyrhiza** Rosenv.

Frond at first a simple filament of a single series of disk-shaped cells, 10–12μ diam., attached to the substratum by a rhizoidal projection from the lower cell; later attached at various parts of the filament by rhizoidal growths, one or two from a cell; increasing in diameter by growth and division of cells, up to 70μ diam.; terete or somewhat irregular in surface, but not flattened; cells with parietal chromatophore and one pyrenoid; in the mature plant showing superficially an arrangement in longitudinal and transverse lines; in cross sections an arrangement by 2–4–8–16, etc., in somewhat *Gloeocapsa*-like form; asexual reproduction by aplanospores, arranged in longitudinal and horizontal series.

Known only from the west shores of Amaknak Island, Alaska.

Rosenvinge, Groenl. Havalg., 1893, p. 937, f. 45, 46; Collins, Green Alg. N. A., 1909, p. 221; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 217; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 914.

The specimens distributed under no. 914 of the Phycotheca Boreali-Americana agree so closely in every way with the description and figures of Rosenvinge that we feel justified in referring them to *Gayella polyrhiza*. They were not associated with anything resembling a true *Prasiola*.

2. **Gayella constricta** S. and G.

Plate 12, figs. 5–10

Filaments small, dark green, somewhat tufted, 1–4 mm. high, 18–20μ diam. at the base, up to 175μ at the apex, cylindrical-clavate, uncinate, constricted at frequent intervals, sparingly branched at the base; cells disk-shaped, 10–15μ diam., at first in a single series throughout, remaining so for some distance at the base, but dividing into groups longitudinally in two or more planes above, increasing the diameter of the filament and preserving its cylindrical form in general through gradually becoming larger, the terminal group of cells having the greatest diameter; at frequent intervals groups of 2–6 cells remain undivided vertically, giving a constricted appearance to the mature plants; cell walls hyaline, homogeneous; cross-walls very thin; chromatophore single, occupying nearly the entire cell; pyrenoid obscure.

Growing in depressions and crevices in rock, above high-tide level, kept moist by dashing salt spray. Discovered at Tomales Point, Marin

County, California. Since its first publication it has been observed in a similar habitat near Friday Harbor, San Juan County, Washington.

Setchell and Gardner, *in* Gardner, New Pac. Coast Mar. Alg. I, 1917, pp. 384, 385, pl. 33, f. 5–9, and pl. 32, f. 5.

Gayella constricta differs from *G. polyrhiza* in having fewer rhizoids and these usually much longer and multicellular. It differs also in having deep constrictions in the mature filaments caused by the failure of certain cells to divide vertically. It differs finally in the much greater diameter of the upper portions of the filaments and in their uncinate tips.

Gayella constricta has been observed in cultures in the laboratory for over eighteen months as well as the *Prasiola* (*P. meridionalis*) found growing with it. In pure cultures no transformation from one to the other was observed. New plants of *Gayella* which were constantly arising retained the *Gayella* form. No plants of *Gayella* arose in pure cultures of the *Prasiola*. It seems to us that these cultures justify keeping the two genera separate as well as establishing the independence of both *Gayella constricta* and *Prasiola meridionalis*.

Order 6. ULOTRICHALES Blackman and Tansley

Frond of branched or unbranched filaments, typically of a single series of cells; cells uninucleate with one or few parietal chromatophores with or without one or more pyrenoids; multiplication by fragmentation, akinetes or aplanospores; reproduction by zoospores and by isogamous or oogamous gametes.

Blackman and Tansley, Class. Green Algae, 1902, p. 137; West, Algae, vol. 1, 1916, p. 281. *Chaetophorales* Wille, *in* Engler and Prantl, Natürl. Pflanzenfam., Nachtr. zum I Theil, 2 Abt., 1909, p. 3.

The Ulotrichales form a fairly compact group of families having the frond branched or simple, and composed of uninucleate cells. The cells are usually in a single series. There are a few exceptional genera, but these usually occur among the fresh water species which constitute the greater portion of the group.

Key to the Families

1. Filaments simple, rarely branched.....11. **Ulotrichaceae** (p. 282)
1. Filaments branched, at times prostrate and concrescent..... 2
   2. Cells green, without haematochrome.....12. **Chaetophoraceae** (p. 286)
   2. Cells normally yellow or red, with haematochrome.....
   .....13. **Trentepohliaceae** (p. 305)

FAMILY 11. ULOTRICHACEAE BORZI

Filament simple, or very rarely branched, fixed to the substratum by a usually specialized basal cell; cells in a single series, or double by concrescence, uninucleate, with a single complete or broken annular chromatophore having one to several pyrenoids; multiplication by fragmentation, akinetes, or aplanospores; zoospores 2- 4-ciliated; isogametes 2-ciliated.

Borzi, Studi Algologici, 1883, p. 25 (*"Ulothriciaceae" sic!*) (in part); Blackman and Tansley, Class. Green Algae, 1902, p. 137. *Ulothricheae* Kuetzing, Phyc. Gen., 1843, p. 251.

The Ulotrichaceae was first designated as a family by Kuetzing (*loc. cit.*). The name in its present form was given by Borzi (*loc. cit.*) although the orthography was incorrect. The contents of Borzi's family was greater than used later by Blackman and Tansley (*loc. cit.*) whose idea we follow. The majority of the Ulotrichales are branched, but there are some with simple filaments and these are all contained in the Ulotrichaceae. Very few of the members of this family show any branching at all, and when they do it is slight compared with that of the members of the Chaetophoraceae or of the Trentepohliaceae. The great majority of the species of the Ulotrichaceae are inhabitants of fresh waters but a few species of *Ulothrix* are marine.

24. **Ulothrix** Kuetz.

Filaments simple or rarely branched, of a single series of uninucleate cells, all similar, and, with the exception of the attached basal cell, capable of division and of producing spores; chromatophore band-shaped, with one or more pyrenoids; asexual reproduction by aplanospores and akinetes, also by 4-ciliated zoospores, with red stigma, formed 1–4 in a cell, germinating immediately; sexual reproduction by 2-ciliated gametes formed 8 or more in a cell, germinating after conjugation; external conditions may induce many modifications of the normal process; akinetes may be formed, ultimately producing zoospores; filaments may break up into individual cells, and these by copious formation of gelatine pass into a *Palmella* or a *Gloeocystis* condition.

Kuetzing, Algolog. Mitth., 1833, p. 517.

The genus *Ulothrix* contains both fresh water and marine species and is to be distinguished from the genera *Hormiscia* and *Chaetomorpha* of the Cladophoraceae by its uninucleate cells. The pyrenoids,

also are less numerous in each chromatophore in *Ulothrix,* the majority of species containing only one.

The species of *Ulothrix* still need careful study especially in cultures. These cultures, however, are not easy to carry on. The filaments vary considerably in diameter in different stages of growth, often increasing very considerably in diameter as they pass over into reproductive condition. The chromatophores of the different species seem distinctly different in the earlier vegetative conditions but lose their character as the cells pass on towards reproductive stages. Wille (1901 and 1906) has made the more recent and more considerable studies of the marine species and has brought out many new points of view, showing how necessary it is to have plants for study in practically all stages of development. Dried plants are often very unsatisfactory in that chromatophore structure is generally difficult of exact determination. Specimens preserved in liquid are much more favorable for investigation.

Key to the Species

1. Filaments always free, no branches 2
1. Filaments often grown together, occasional branches .....4. **U. laetevirens** (p. 286)
2. Cells (especially fertile) much shorter than broad 3
2. Cells (including fertile) usually as long as, or longer than broad .....1. **U. implexa** (p. 283)
3. Chromatophore a complete ring, fertile filaments broad (up to 60μ or even 80μ diam.) .....2. **U. flacca** (p. 284)
3. Chromatophore an incomplete ring, fertile filaments much narrower (not over 38–40μ diam.) .....3. **U. pseudoflacca** (p. 285)

1. **Ulothrix implexa** Kuetz.

Plants light green, forming soft masses, cells 6–15μ diam., sometimes slightly swollen at the middle, nearly quadrate, chromatophore, when young, occupying only the middle part of the cell, often an incomplete ring; fertile cells nearly quadrate, not swollen or increased in width.

Growing on rocks near the mouths of streams, and on wood in quiet water, in the littoral belt. Alaska (St. Michael) to California (San Francisco).

Kuetzing, Sp. Alg., 1849, p. 349; Collins, Green Alg. N. A., 1909, p. 185; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 217. *Ulothrix subflaccida* Wille, Stud. ueb. Chloroph., I–VII, 1901, p. 27, pl. 3, f. 90–100 (?); Collins, Green Alg. N. A., 1909, p. 186; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1275.

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Wille (1901, p. 22) has raised the question as to the exact nature of the type of this species and as to the status of other plants referred to it. Hazen (1902, p. 155) thinks, however, that Wille's doubts are not founded on sufficient basis for rejecting the name and that the type of *U. implexa* may be reckoned among the marine species.

We have followed the usual fashion of referring here our most slender species whose cells are usually as long as, or often longer than, broad. The chromatophore in young cells in active vegetative condition forms a more or less complete band about the middle of the outer cell wall. Many of our specimens, however, seem to have a complete chromatophore clothing the entire outer wall. We are inclined to consider the cells of such specimens as probably passing over into the fertile condition, but not, as yet, having undergone division to form zoospores or gametes. The fertile cells in these species are neither enlarged (i.e., broadened) nor swollen. A careful study of living material in various stages will be very helpful in clearing up these matters.

We follow Hazen in placing the *Ulothrix subflaccida* Wille (*loc. cit.*) as a synonym under *U. implexa*.

2. **Ulothrix flacca** (Dillw.) Thur.

Plants forming bright or dark green, often much entangled, masses or skeins; cells 10–25μ diam., 0.25–0.75 as long as broad, when producing spores up to 50μ diam., and swollen in the middle; chromatophore occupying the whole of the cell wall with 1 to 3, occasionally more, pyrenoids.

Growing on other algae, on rocks and on wood, in the littoral belt. From Alaska to California.

Thuret, *in* Le Jolis, Liste Alg. Mar., 1863, p. 56; Collins, Green Alg. N. A., 1909, p. 185; Saunders, Alg. Harriman Exp., 1901, p. 412; Setchell and Gardner, Alg. N.W. Amer., 1903, p. 217; Hazen, Uloth. and Chaetoph. U. S., 1902, pl. 20, f. 7–9. *Conferva flacca* Dillw., Brit. Conf., 1809, pl. 49.

We can not feel certain whether the *Ulothrix flacca,* as it has been finally limited by Wille (1901, p. 18 *et seq.*) is the *Conferva flacca* of Dillwyn (*loc. cit.*) or not. There is a certain strong suggestion to our minds of *Ulothrix pseudoflacca* Wille in both the figures and the description of Dillwyn. It seems best, however, to follow the present conception of the species and assign under *U. flacca* marine *Ulotriches*

which, while comparatively slender (10–25μ diam.) in the vegetative condition, thicken very considerably (up to 60μ or even 80μ) when producing zoospores or gametes. The cells when younger may be almost or quite quadrate, but become in the fertile condition very much shorter than the diameter.

3. **Ulothrix pseudoflacca** Wille

Filaments 8–32μ diam., free from one another, attached by an elongated, downwardly gradually tapering cell; cells from 0.25 as long as broad to nearly quadrate; cell walls thin; chromatophore parietal, completely covering the outer cell wall, thickened in the region of the single pyrenoid, fertile cells not exceeding the vegetative in diameter, from flattened to nearly globular.

On rocks and algae, upper littoral belt. Alaska (Sitka) to California (San Francisco).

Wille, Stud. ueb. Chloroph., 1901, p. 22, pl. 2, f. 64–81.

Ulothrix pseudoflacca varies as follows: f. *minor* Wille (*loc. cit.*, p. 23, pl. 2, f. 67–69), 8–16μ diam.; f. *major* Wille (*loc. cit.*, p. 23), 10–22μ diam.; f. *maxima* Setchell and Gardner (*in* Gardner, 1919, p. 488, pl. 42, f. 6), 28–32μ, up to 40μ diam. Plate 9, fig. 6 A, B.

Of these f. *minor* has been collected at Sitka, Alaska, f. *major* and f. *maxima* at Lands End, San Francisco, California (all by Gardner).

Ulothrix pseudoflacca bears a considerable resemblance to *U. flacca* except that in its fertile condition it does not reach so considerable a diameter and the fertile cells are usually more or less rounded. The chromatophore in *U. pseudoflacca* is a broken ring while that of *U. flacca* is a complete ring.

Ulothrix pseudoflacca varies much in diameter and, as shown above, may be separated more or less readily into three overlapping forms, the f. *minor* approximating forms of *U. implexa* in slenderness, while f. *maxima* approaches forms of *U. flacca*. As filaments of *U. pseudoflacca* approach the fertile condition, it is difficult to detect the gap in the chromatophore.

Jónsson (1904, pp. 55–57) has reviewed this species as well as others of the genus and has made valuable suggestions. He has also described a related new species (*loc. cit.*, pp. 57–60, f. 8, 9), *Ulothrix scutata*, which has not been thus far detected among the specimens available from our territory.

4. **Ulothrix laetevirens** (Kuetz.) Collins

Filaments 10–25μ diam., two or three often firmly grown together laterally, more or less entangled and creeping; with not infrequent branches, issuing at a wide angle, and usually much more slender than the main filament, of many cells, which are generally 1–3 diam. long; filaments tapering towards the base, the lower cells of the densely packed filaments often subparenchymatously united; cells 0.25–0.75 diam. long, rarely more; chromatophore covering nearly or quite all of the cell wall, but thicker at one side, where the pyrenoid is situated; zoospores usually 8 in a cell; akinetes formed singly from the cells.

On woodwork between tides. Alaska (Unalaska and Sitka) to California (fide Collins).

Collins, Green Alg. N. A., 1909, p. 186. *Schizogonium laetevirens* Kuetzing, Phyc. Germ., 1845, p. 194. *Ulothrix consociata* Wille, Stud. ueb. Chloroph., I–VII, 1901, p. 25, pl. 2, f. 82–89, Algol. Unters., I–VII, 1906, p. 12, pl. 1, f. 30, 31 (*fide* Collins).

Collins (1909, p. 186) considers that *Schizogonium laetevirens* Kuetz. and *Ulothrix consociata* Wille are identical. He formed his opinion after examining a topotype of Kuetzing's species. We have adopted this opinion, but have formed our idea of the species upon the description and figures of Wille. Our specimens show fairly frequent branches and filaments laterally coalescent. In dimensions, both of vegetative and fertile segments and cells, our specimens agree closely with the plant described and figures by Wille. The plant has a considerable likeness to *U. pseudoflacca* Wille, but it is to be distinguished by its tendency to branch and to have coalescent filaments.

FAMILY 12. CHAETOPHORACEAE DE-TONI AND LEVI

Frond of more or less branched filaments, erect or prostrate, at times enclosed in a more or less gelatinous envelope; cells uninucleate, green, without haematochrome, the terminal often acute or forming a colorless hair; chromatophore parietal, band-shaped, at times annular, containing one or more pyrenoids; propagation vegetative, by akinetes or by aplanospores; zoospores of two sorts, macrozoospores and microzoospores, 2- 4-ciliated, usually produced from modified cells; 2-ciliated isogametes and heterogametes known in some genera; setae of various kinds present in some genera.

De-Toni and Levi-Morenos, Fl. Alg. Venez., III, 1888, p. 171 (Repr.); Blackman and Tansley, Class. Green Alg., 1902, p. 138. *Chaetophoroideae* Harvey, Man. Brit. Alg., 1841, p. 10 (in part).

The Chaetophoraceae form a family of both fresh-water and marine species. The latter are nearly all prostrate epiphytes or endophytes, living upon the larger Chlorophyceae, Melanophyceae and Rhodophyceae. The species of one genus on our coast bores into shells. There are doubtless a number of genera and species of this family on our coast still awaiting discovery.

The Chaetophoraceae are generally divided into five tribes, four of which are represented on the Pacific Coast. *Bulbocoleon* represents the Chaetophoreae, *Entocladia* belongs to the Leptosireae, *Ulvella Pseudulvella* and *Pseudopringsheimia* belong to the Ulvelleae, *Gomontia* belongs to the Gomontieae, while *Internoretia, Endophyton* and *Pseudodictyon* are not definitely placed as yet owing to a lack of knowledge of the details of the processes of reproduction.

Key to the Genera

1. Cells dividing in one or two planes, forming simple branched filaments 2
1. Cells dividing in three planes, forming solid branched filaments ..... 29. **Internoretia** (p. 294)
2. Cells occasionally piliferous ..... 25. **Bulbocoleon** (p. 287)
2. Cells never piliferous 3
3. "Sporangia" with rhizoid-like projections (shell borers) ..... 33. **Gomontia** (p. 300)
3. "Sporangia" rounded, destitute of rhizoid-like projections (not shell borers) 4
4. Chromatophores destitute of pyrenoids ..... 30. **Ulvella** (p. 295)
4. Chromatophores provided with pyrenoids 5
5. Cells not coalescing to form a pluristratose layer 6
5. Cells coalescing to form a pluristratose layer, at least in center 8
6. Filaments radiating, often coalescing in the central portion ..... 26. **Entocladia** (p. 288)
6. Filaments not radiating, never coalescing 7
7. Filaments anastomosing to form a network, endophytic ..... 28. **Pseudodictyon** (p. 293)
7. Filaments free, not forming a network, endophytic ..... 27. **Endophyton** (p. 292)
8. Thallus destitute of penetrating rhizoids ..... 31. **Pseudulvella** (p. 296)
8. Thallus provided with penetrating rhizoids ..... 32. **Pseudopringsheimia** (p. 299)

25. **Bulbocoleon** Pringsheim

Thallus minute, epi- or endophytic in various lubricous or gelatinous algae of loose tissues; filaments creeping, branching, of irregularly shaped cells, rounded or somewhat elongated horizontally; bearing on the upper sides of the filaments single or clustered rounded cells prolonged into long, hyaline, unseptate hairs; chromatophore of

the non-piliferous cells; plate-like, perforate, with 5–10 pyrenoids, that of the piliferous cells, irregular and toothed, with 2 pyrenoids; zoospores (?) 2-ciliated, produced from non-piliferous cells somewhat enlarged on the upper side.

Pringsheim, Beitr. z. Morph d. Meeresalg., 1862, p. 1; Collins, Green Alg. N. A., 1909, p. 283.

The species of *Bulbocoleon* are those members of the Chaetophoraceae whose cells are in branching filaments which bear groups of specialized cells produced into continuous (i.e., non-septate) hairs. They are generally endophytic in gelatinous brown and red algae and have 2-ciliated zoospores. Little is known of this genus on our coast and it seems more than likely that related genera provided with hairs may also be found. Careful search and examination should be made for *Bulbocoleon* and other piliferous genera of the family Chaetophoraceae in and on the gelatinous or lubricous species of brown and red algae of our coast.

Bulbocoleon piliferum Pringsheim

Non-piliferous cells 12–16μ diam., 2–3 times as long as broad.

On *Cumagloia Andersonii* (Farlow) S. and G. Southern California (San Pedro).

Pringsheim, Beitr. z. Morph. d. Meeresalg., 1862, p. 8, pl. 1; Hazen, Ul. and Chaet. U. S., 1902, p. 227; Collins, Green Alg. N. A., 1909, p. 283.

Thus far, *Bulbocoleon piliferum* has been detected only in the fronds of *Cumagloia Andersonii* in southern California (San Pedro, Miss S. P. Monks, Mrs. H. D. Johnston). It is likely to occur along our coast northward to the region of Puget Sound at least, and also on other species of algae such as those of *Mesogloia, Leathesia, Scytosiphon, Chorda, Ralfsia,* etc. It occurs at times so abundantly as to discolor the host, but often is to be found in small quantity, giving no outward (or macroscopic) indication of its presence.

26. **Entocladia** Reinke

Plants microscopic, composed of creeping, irregular, much branched filaments, without hairs, growing on or within aquatic plants; growth mostly by division of terminal cells; chromatophore a parietal band with one or more pyrenoids; reproduction by 2-4-ciliated zoospores.

Reinke, Zwei par. Algen, 1879, p. 476. *Endoderma* Lagerheim, Bidr. Sver. Alg., 1883, p. 74. *Entoderma* Wille, Chlorophyceae, *in* Engler and Prantl, Natürl. Pflanzenfam., 1890, p. 94.

It seems desirable to restore the earlier name of *Entocladia,* since it differs in one letter from the earlier *Endocladia* J. Ag. (1841) and belongs to an entirely different class of algae. There seems, therefore, to be little likelihood of any serious confusion. The genus is now credited with several species, some of which occasionally possess hairs. It seems best to us to restrict the generic name to species without hairs. One characteristic of the genus is supposed to be the habitat, viz., growing within the cell membranes (or cuticula?) of various green, brown and red algae. It does not seem to us that this manner of growth ought to receive too great emphasis in determining the generic limits. Removal of this, as a criterion of generic distinction, would probably result in the combination of the genus *Epicladia* Reinke with the genus *Entocladia* Reinke. Since we have not as yet detected a species of *Epicladia* on the Pacific Coast, we may leave discussion of this point to others, but we may instance the genus *Coleochaete* as possessing a species endophytic in the membranes of the segments of *Nitella* while most of the rest of the species are epiphytic.

Key to the Species

1. Filaments scarcely if at all coalescing.....1. **E. viridis** (p. 289)
1. Filaments coalescing, at least at the center..... 2
2. Free filaments numerous and long.....2. **E. codicola** (p. 290)
2. Free filaments few, short.....3. **E. cingens** (p. 291)

1. **Entocladia viridis** Reinke

Filaments branching freely, 3–8μ diam., cells 1–6 diam. long, cylindrical, or more often irregularly swollen and contorted; chromatophore nearly covering the cell wall and containing a single pyrenoid.

Growing on *Callithamnion Pikeanum.* Central California (Moss Beach, San Mateo Co.).

Reinke, Zwei par. Algen, 1879, p. 476, pl. 6, f. 6–9. *Endoderma viride* Lagerheim, Bidr. till Sver. Alg., 1883, p. 74; Collins, Green Alg. N. A., 1909, p. 279; Collins, Holden and Stechell, Phyc. Bor.-Amer. (Exsicc.), no. 2236.

We have not been able to make a satisfactorily extensive study of the *Entocladia* species apparently not uncommon in the cell and other membranes of our various marine algae. Consequently we have

neither determined, to our satisfaction, whether true *E. viridis* occurs on our coast nor the number of species of its general type ultimately to be found in our territory. We have, therefore, merely recorded the specimens already distributed in the Phycotheca Boreali-Americana (no. 2236).

2. **Entocladia codicola** S. and G.

Plate 19, fig. 7

Filaments light green, branching profusely, at maturity forming a continuous layer in the center of the mass with tapering free ends around the margin; young cells 3–4μ diam., 1–2.5 times as long, terminal cells slender and conical; cells in the center of the thallus 5–8μ diam.; pyrenoids single; reproduction unknown.

Growing in the membrane, at the tips of the utricles of *Codium fragile*. Central and southern California.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 293, pl. 24, fig. 7 a, b.

Entocladia codicola seems closely related to *Entocladia viridis* Reinke (1879, p. 476, pl. 6, f. 6–9), found growing in the membrane of *Derbesia;* but it is a larger plant with the filaments much more compact in the center, forming, in fact, a pseudo-parenchymatous disk with free filaments around the margin. The cells are shorter than those of *E. viridis,* some being even shorter than the diameter. In the pseudo-parenchymatous character of the center of the disklike frond it resembles *Epicladia Flustrae* Reinke (1888, p. 241, nomen nudum, 1889, p. 31, pl. 24, 1889*a,* p. 86), but the dimensions given for that species are greater in general than those in ours. Reproductive bodies have been observed in the cells of the central portion of the disk in *E. codicola,* but the nature of these, their method of escape, and their subsequent behavior have not been determined. Until more is known concerning these later phases of the plant, its proper placing must remain somewhat in doubt. It is here placed provisionally with *Entocladia* on account of its endophytic habit of growth, rather than with *Epicladia,* which has the habit of growing on the outside of the host. This habit of growth seems to be the only one by which the two genera are distinguished, so far as the diagnoses reveal. Little, however, is known concerning the reproduction in *Epicladia,* and until that matter can be cleared up it can have but little claim to generic distinction. Reinke expressed doubt as to the validity of the genus when he diagnosed it (1889). Collins (1909) has retained

both genera, and under *Endoderma* (*Entocladia*) has included two species, viz. *E. Pithophorae* West and *E. polymorphum* West, which are epiphytic, and thus, as he remarks (*loc. cit.*, p. 280), "connects *Endoderma* with *Epicladia*, but the filaments do not unite to form a definite disk."

Entocladia codicola seems to be confined to the coast of California and to the above mentioned host plant, at least examination of considerable material of different species of *Codium* in different localities, ranging from Sitka, Alaska, to southern California, has not revealed its presence elsewhere.

3. **Entocladia cingens** S. and G.

Plate 18, fig. 7

Thallus early forming a pseudo-parenchymatous tissue surrounding the filaments of the host within the membrane, having a few marginal filaments extending parallel with the long diameter of the host; cells in the center of the thallus nearly isodiametric, 5–8μ diam., enlarging later to form sporangia; cells of the free marginal filaments 3–4μ diam., 2–3 times as long as the diameter, terminal cells long, conical.

Growing within the membrane of *Chaetomorpha californica* Wille. Southern California (Ocean Beach, near San Diego).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 292, pl. 23, fig. 7.

The plants of this species seem to be nearing maturity in December, since a few empty cells in the center of the thallus were found from which reproductive bodies probably had escaped. Aside from this condition, nothing further is known of its method of reproduction.

Entocladia cingens is placed in this genus on account of the resemblance of the vegetative development to that of the type species, *E. viridis* Reinke, and because of the same endophytic habit as that species. It differs from *E. viridis* in having the branching filaments more closely coalescent, the enlarging cells in the main part of the thallus soon forming a pseudo-parenchymatous tissue, leaving only a few free marginal filaments.

E. viridis, *E. codicola*, and *E. cingens* form a well connected series, using the vegetative characters as a basis. The first named species has a rather wide-spreading thallus, composed of relatively sparsely branching filaments, scarcely, if at all, coalescing in the center. In the second, the filaments coalesce freely in the center so that at least

half of the thallus is formed into a pseudo-parenchymatous tissue at the time of reproduction, but leaving an abundance of free branching marginal filaments. The thallus of the third is almost wholly transformed into a pseudo-parenchymatous tissue at maturity, leaving only a few free marginal filaments.

27. **Endophyton** Gardner

Filaments sparingly and irregularly branched within the medulla of the host, but branching more freely near the surface, sending off in addition to horizontal branches many short, erect branches perpendicular to the frond, the end cells of the perpendicular branches becoming the sporangia and growing out to the surface of the host; chromatophore band-shaped; each cell containing a single pyrenoid; zoospores pyriform, 2-ciliated.

Endophytic within the fronds of various species of red algae.

Gardner, New Chlorophyceae, 1909, p. 371; West, Algae I, 1916, p. 304.

This is a form genus, whose cytology is at present too little known. In its habit, it is more thoroughly endophytic than any other genus of the Chaetophoraceae, since its filaments traverse the medullary as well as the cortical tissues of its hosts. The absence of hairs and specialized zoosporangia seem to mark it as distinct.

Endophyton ramosum Gardner

Plate 11, figs. 3, 4

Filaments 4–6μ diam., tortuous, often very irregular in shape; cells 6–8 times longer than broad, cross-walls distinct; sporangia club-shaped, tapering to a point at the outer end, when young 10–12μ diam.; zoospores numerous, 3μ diam., escaping through openings in the upper ends of the sporangia which grow to the surface of the host; plants occupy small areas a few millimeters in diameter, usually near the base of the frond of the host, but may spread promiscuously over the entire area of the host.

Endophytic within the fronds of various species of red algae, e.g., *Iridaea laminarioides, Gigartina exasperata,* etc. Central California (San Francisco) and probably farther north.

Gardner, New Chlorophyceae, 1909, p. 372, pl. 14, f. 3, 4; Collins, Green Alg. N. A., 1909, p. 282; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1627.

The presence of this endophyte in the fronds of species of *Iridaea*, *Gigartina* and possibly also of *Nitophyllum* is indicated externally by spots of a much redder color than that of the uninfested portions of the host. Its detection at other points than about San Francisco will probably follow careful search for it on similar hosts.

28. **Pseudodictyon** Gardner

Thallus much branched, the main filaments comparatively long and tortuous, creeping among the cells of the cortical layer of the host plant (*Laminaria* sp.), branching freely; the branches, usually arising at right angles to the main filaments and bending backward among the cortical cells, unite into a sort of net; a very short erect branch composed of two or three cells arises from practically every cell of the horizontal filaments in the central portion of the thallus; the uppermost cell of each erect branch becomes a sporangium and grows to the surface of the host; each cell contains a single peripheral chromatophore with one pyrenoid; reproduction unknown.

Gardner, New Chlorophyceae, 1909, p. 374; West, Algae I, 1916, p. 304.

Since neither the cytology nor the reproduction of the type and only species thus far referred to this genus, has been studied, it exists merely as a form genus of probably close relationship to *Entocladia*. It is to be hoped that some one having favorable opportunity may add much that is desirable to our knowledge of this seemingly very distinct endophytic genus.

Pseudodictyon geniculatum Gardner

Plate 11, figs. 5, 6

The young, creeping filaments 3–4μ diam., becoming larger with age; tips of the geniculate filaments seem to coalesce with neighboring cells, giving the young plant the appearance of a fine net, the meshes enclosing 4–8 cells of the host plant; sporangia 8–12μ diam.; cell walls thin and cross walls distinct.

Growing in abundance in the terminal parts of the blade of *Laminaria Sinclairii*. San Francisco Bay, California.

Gardner, New Chlorophyceae, 1909, p. 374, pl. 14, f. 5, 6; Collins, Green Alg. N. A., 1909, p. 283; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1628.

The host plant of "a" of the above distribution is *Laminaria Sinclairii;* and the host of "b" of the same distribution is *Dictyoneuron californicum*. The plants under "b" are not quite typical, but with our present knowledge seem too closely related to the typical form to warrant separation from it. Its life history has not been studied. The "net" character of the thallus is much less regular than in the typical form. This may be due to the character of the cells of the host plant.

29. **Internoretia** S. and G.

Thallus endophytic, consisting of profusely branched filaments, at first of a single series of cells increasing by apical divisions perpendicular to the long diameter, but later, by oblique and longitudinal divisions, building up cylindrical threads composed of numerous cells in cross diameter; branching at right angles, anastomosing, forming a network; chromatophore parietal, with one pyrenoid; reproduction unknown.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 294.

The genus *Internoretia* was proposed for a peculiar endophyte found by Professor T. C. Frye, growing within the membranes of *Porphyra*. Its reproduction not having been determined, it is added to the numerous form genera of uncertain position and placed provisionally among the Chaetophoraceae. It resembles *Pseudodictyon* Gardner and *Zygomitus* B. and F. From the former it differs in forming solid filaments several cells in thickness. From *Zygomitus*, *Internoretia* differs in the greater regularity of its solid portions, and in the more uniform network brought about by the regular giving off of branches at right angles.

Internoretia Fryeana S. and G.

Plate 18, figs. 3–6

Cells of the terminal filaments 3.5–5μ diam., 3–5 times as long, apical cell conical; cells of the older part of the thallus isodiametric, angular; otherwise as the genus.

Growing within the membrane of *Porphyra Naiadum*. Friday Harbor, Washington.

Setchel land Gardner, Phyc. Cont. I, 1920, p. 295, pl. 23, figs. 3–6.

This most interesting little plant is as yet known only from the collections and observations of Professor T. C. Frye. It generally occurs in such abundance as to discolor the host plant. In some years

it is very common, discoloring most of the plants of *Porphyra* in the neighborhood of the Puget Sound Marine Station, while in other years it is difficult to find any plants at all.

30. **Ulvella** Crouan

Thalli forming small disks on larger plants or other objects, firmly attached by the under surface, unistratose at first, later, at times, pluristratose, of radiating, laterally united, dichotomous filaments; segments multinucleate, with parietal chromatophore and no pyrenoid; 2-ciliated zoospores formed in the central cells, 4–8–16 in a cell, escaping by an opening at the top.

Crouan, Notice sur quelq. nouv. algues mar., 1859, p. 288, pl. 22, f. E; Wille, Nachträge, 1909, p. 89.

The genus *Ulvella* is based upon *Ulvella Lens*, found growing upon bits of porcelain and glass at Brest, France. The original specimens have been examined by Huber (1893, p. 295), who has figured the type (*loc. cit.*, pl. 11, f. 4–6) and added to our knowledge of its morphology and cell structure. It is a prostrate, unistratose or paucistratose, discoid plant composed of radiating filaments with no trace of hairs and whose terminal cells fork before dividing. The chromatophore is single and devoid of a pyrenoid. Nothing is known of the reproduction of the type of the species. It has come to be generally accepted that *Dermatophyton radians* Peter, a species inhabiting the carapaces of fresh water tortoises in southwestern Europe, is also to be referred to *Ulvella* (cf. Schmidle, 1899, Wille, 1909, p. 89) and the characters of multinucleate "cells" and 2-ciliated zoospores considered to be characteristic for the genus. Unfortunately, we do not know whether these characters hold for the type species, *Ulvella Lens*. We also unfortunately do not know whether they hold for the single species of our coast which we are inclined to refer under this genus and also to *Ulvella Lens*. It is to be hoped that further information may be obtained at some favorable opportunity.

Ulvella Lens Crouan

Plate 33

Thallus orbicular, bright green, 150–250μ, up to 1.5 mm. diam.; marginal segments usually cuneate, 3.5–4.5μ diam., 15–25μ long with terminal growth, central segments 8–15μ diam.

Growing firmly attached to *Laurencia* sp. in the upper sublittoral belt. Central California (Pacific Grove).

Crouan, *loc. cit.;* Huber, Contributions des Chaetophorées, 1892, p. 294 *et seq.,* pl. 11, f. 4–6; Collins, Green Alg. N. A., 1909, p. 286; Wille, Nachträge, 1909, p. 89.

We feel compelled to refer here a plant found in abundance on a species of *Laurencia* at Pacific Grove, California, in July. In general appearance, in structure, in dimensions of the cells and manner of peripheral growth, the specimens correspond exactly with the figures and description of Huber (*loc. cit.*) for the type material of *Ulvella Lens.* Our plants, however, have only been detected, thus far, as epiphytes. We have seen, in our preserved material, the central cells both empty and divided into 8 rounded bodies, probably zoospores. Unfortunately we have not preserved specimens in a condition suitable for the study of the number of nuclei in the cells.

31. **Pseudulvella** Wille

Thalli forming small disks, composed of radiating filaments closely placed, coalescent and finally more or less loosely pluristratose towards the center, unistratose and more or less free and dichotomous towards the periphery; cells uninucleate, with a single parietal chromatophore containing a single pyrenoid; zoospores 4-ciliated.

Wille, Nachträge, 1909, p. 90. *Ulvella* Snow, *Ulvella americana* 1899, p. 309 (in part).

The genus *Pseudulvella* is said to differ from *Ulvella* in that the cells of its species have only a single nucleus, the chromatophore has a single pyrenoid and the zoospores are 4-ciliated. It is said to differ from *Pseudopringsheimia* in the lack of rhizoid-like filaments which penetrate the host. It is placed by Wille (*loc. cit.,* p. 79) among the genera whose species lack hairs, although Snow (1899, p. 310) says that "in quite a number of cases, long gelatinous hairs extended from the surface" in the type species, *Ulvella americana* Snow. This statement as to hairs undoubtedly led Collins (1909, p. 289) to refer the *Ulvella americana* Snow to *Chaetopeltis.* Since Snow does not figure the hairs and the statement seems little convincing, we are inclined to follow Wille in presuming that no hairs are present.

Key to the Species

1. Basal layer of more or less distinctly radiating filaments 2
1. Basal layer distinctly parenchymatous ..... 3. **P. applanata** (p. 298)
2. Radiating filaments loosely coalescent ..... 1. **P. prostrata** (p. 297)
2. Radiating filaments closely coalescent ..... 2. **P. consociata** (p. 297)

1. **Pseudulvella prostrata** (Gardner) S. and G.

Plate 11, figs. 1, 2

Thallus 2–3 mm. diam. consisting of 2–3 layers of cells in the center, but of a single layer at the margin, formed by branching filaments growing out radially on the host, coalescing in the central part of the thallus but free from each other around the margin, and adhering very firmly to the host; filaments branched, 6–7μ diam., nearly uniform in diameter throughout their entire length; cells quadrate in the center of the thallus, those at the outer ends of the filaments 1.5–2.5 times as long as broad; color very dark green; end cells blunt, each containing a single peripheral chromatophore and one pyrenoid.

Growing on the basal portion of *Iridaea laminarioides*. Central California (Lands End, San Francisco).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 295. *Ulvella prostrata* Gardner, New Chlorophyceae, 1909, p. 373, pl. 14, f. 1, 2; Collins, Green Alg. N. A., 1909, p. 287; Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 1629.

Although we know too little of the *Ulvella prostrata* Gardner both from the point of view of its cytology and of the nature of its zoospores, it cannot remain in *Ulvella* because of the presence of a pyrenoid in the chromatophore. It does not possess the penetrating rhizoidal filaments supposed to be characteristic of *Pseudopringsheimia*. It does, however, resemble *Pseudulvella americana* (Snow) Wille sufficiently closely in its general structure to be referred to the same genus for the present at least.

2. **Pseudulvella consociata** S. and G.

Plate 19, figs. 4–6

Thallus irregular in size and in outline, 100–140μ thick, increasing by irregular and obscurely radiating filaments early coalescing and becoming parenchymatous; color dark green; erect filaments firmly coalescent, 7–10μ diam., cells nearly cylindrical, slightly irregular in form, 1–2 times as long as the diameter; zoosporangia (?) terminal, pyriform to spherical, producing 8 zoospores.

Growing on the shells of *Ilyanassa obsoleta* Say. Central California (Bay Farm Island, Alameda).

Setchell and Gardner, Phyc. Cont. I, 1920, p. 296, pl. 24, fig. 4–6.

The shells of *Ilyanassa obsoleta* were introduced some years ago along with oysters from the Atlantic coast of North America, and possibly the plant here described was introduced with the host.

The comparison of this species with others will be found included in the discussion under *P. applanata.*

3. **Pseudulvella applanata** S. and G.

Thallus thin, parenchymatous, spreading by marginal growth, expanded to several mm. in diam., smooth and glossy, 45–55μ thick; color grass green; cells in fairly regular vertical rows nearly isodiametric, sharply angled, 6–7.5μ diam.; chromatophore covering the cell wall, provided with one pyrenoid; zoosporangia (?) slightly modified surface cells; reproduction unknown.

Growing on the shells of *Littorina planaxis* Nutt. Central California.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 295.

Littorina planaxis is very abundant in small tide pools and in moist places along high-tide level from Sitka to San Diego. *Pseudulvella applanata* has been studied only on material found along the coast of central California, but it is presumed to have a much wider distribution.

Its presence on the host is readily recognizable by its expanded, grass green, glossy appearance. Microscopically it may readily be distinguished from all other described species of the genus by its very small, closely compact, parenchymatous cells, and its seeming absence of radiating filaments composing the basal layer. It spreads over the host by tangential and by radial divisions of the peripheral cells, at least it can thus be stated when the plant is of considerable size. It probably starts on the very young host, and doubtless many plants early coalesce to form a confluent thallus. We have never been able to ascertain the nature of the early developmental stages, although even very small shells have been examined.

Reproductive bodies have been seen to escape from the surface cells. Whether they are zoospores or gametes, the number of cilia they posses, and their behavior after escaping are subjects for further investigation.

The three species of *Pseudulvella* treated of in this paper may be arranged, so far as the basal layer is concerned, in the following sequence: *P. prostrata,* with distinctly radiating basal filaments

which branch rather frequently and which are comparatively loosely coalescent; *P. consociata*, with indistinctly radiating basal filaments closely coalescent; and *P. applanata*, with a parenchymatous basal layer.

32. **Pseudopringsheimia** Wille

Thallus cushion-shaped, epiphytic, often penetrating the hosts at intervals, or growing upon the shells of mollusks; increase in diameter produced by terminal growth of radiating filaments branching frequently and coalescing to form a parenchymatous basal layer; increase in thickness produced by horizontal divisions of the cells of the basal layer forming a mass of erect filaments sometimes branching in turn; cells without hairs containing one chromatophore in the outer end, and one pyrenoid; zoosporangia mostly terminal on the erect filaments or occasionally subterminal as well.

Wille, Nachträge, 1909, pp. 88, 89.

The genus Pseudopringsheimia was founded on the two species, *Ulvella confluens* Rosenv. and *U. fucicola* Rosenv. The particular characteristic separating the genus, especially from *Pseudulvella* Wille is the presence of rhizoidal outgrowths from the base penetrating the host plant. In other respects the species of *Pseudopringsheimia* closely resemble those of *Pseudulvella*. It is a question as to how important such structures as penetrating rhizoids should be estimated as being in separating genera, but since Wille has separated the two genera and since we have altogether too little knowledge of their reproductive processes, it seems best to recognize both for the present.

Pseudopringsheimia apiculata S. and G.

Plate 17, figs. 1, 2

Thallus minute, 145–160μ thick, hemispherical when alone, but often with many crowded closely together forming a continuous stratum 2–3 mm. diam.; color bright green; erect filaments 8–12μ diam., composed of 9–12 cylindrical or slightly swollen cells; rhizoids aggregated into short conical fascicles; zoosporangia (?) producing 8 zoospores, terminal, slightly swollen, varying from convex to decidedly apiculate; zoospores (?) 4-ciliated.

Growing on the rhachis and the cysts of *Egregia Menziesii*. Central California.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 297, pl. 22, figs. 1, 2.

Pseudopringsheimia apiculata is closely related to *P. confluens* (Rosenv.) Wille. The most conspicuous difference is to be found in the shape and size of the zoosporangia, if the terminal reproductive cells are to be designated as such. Those of *P. confluens* are long and comparatively narrow, and produce 30–40 zoospores, while in *P. apiculata* they are shorter, somewhat swollen, mostly with a pronounced terminal projection, and produce about 8 zoospores. These reproductive bodies are very small, and it is exceedingly difficult to determine the number of cilia. On one occasion four cilia were observed but the reproductive bodies seemed a little larger and somewhat more irregular in form than the average. These may have been the zygotes formed by the fusion of 2-ciliated gametes, but had not yet come to rest.

33. **Gomontia** Born. and Flah.

Thallus consisting of creeping, freely branched, septate filaments, from the under side of which many erect, more or less branched filaments arise; cells irregular in shape and size, uninucleate, occasionally multinucleate, with parietal, band-form or shield-shaped chromatophore covering the whole or part of the cell, or a network extending through the cell, with one or two pyrenoids; reproduction by zoosporangia, producing a few egg-shaped zoospores with 4 cilia, by large, irregularly shaped, thick walled, gametangia (?) with rhizoidal outgrowths, producing 2-ciliated gametes (?) whose conjugation is unknown, and by similar large cells producing aplanospores.

Bornet and Flahault, Note sur deux algues, 1888, p. 163 (Repr., p. 5); Sur quelq. pl. viv. dans le test calc., 1889, pp. clii-clx, pl. 6–8, 10, fig. 3.

The genus *Gomontia* is composed of species having the peculiar and presumably distinctive habit of boring into calcareous material. They are usually to be found boring into shells of mollusks, chiefly lamellibranchs, of both fresh and salt waters. One species (*G. codiolifera* (Chodat) Wille), however, bores (?) into limestone rocks. We have considered, as chief characteristic of this genus, the formation of large "sporangia" (gametangia (?) and aplanosporangia) which are usually provided with one or more rhizoid-like appendages. In some species, however, there seem to be no such appendages (e.g., *G. arrhiza* Hariot). The "sporangia" arise as segments of the branching filaments. These segments enlarge and give off processes, finally

the walls thicken more or less and the "rhizoids" often thicken so as to become entirely solid or, at least, throughout the greater portion. The "sporangia" vary considerably in shape and size, even in specimens inhabiting the same shell, and at times exhibit extraordinary differences, but at other times closely follow a particular type. It has been puzzling to us to interpret this variation. As a result of considerable experience, however, we are inclined to lay more stress on distinctions of form and size in the "sporangia" than has been done by others.

In connection with any attempt to examine carefully and critically the various specimens of *Gomontia* as to their identity with, or distinctness from, the eight or more species already described, it has become necessary to examine carefully the type of the species, viz., *Gomontia polyrhiza* (Lager.) B. and F. We have two sources of information as to the type species, viz., the original description and figures of Lagerheim (1885) and the careful and detailed description and figures of Bornet and Flahault (1888). For reasons which we shall give below, we are inclined to suspect that the plant of Bornet and Flahault is a different species from that of Lagerheim, and our suspicion is so strong that we have felt it necessary (cf. Setchell and Gardner, 1920, p. 298) to bestow upon it a new specific name, viz., *G. Bornetii* S. and G. In carrying out the idea that the "sporangia" furnish diagnostic characters, we have separated several species which present difficulties, to be sure, in narrow diagnosis, but which seem rather more satisfying than the attempt to lump all under the one name. The explanation of the variability may possibly be that the different texture of the various species of shells, or of different portions of the same shell, affect the size and shape, but there does not seem to be evidence forthcoming to support this idea. It seems possible that two, or even more, species may be inhabitants of the same shells and thus cause an intermingling of different types of "sporangia." In our attempt to clear up the situation, we have assumed the possibilities of distinct species, at times, intermingled.

Key to the Species

1. "Sporangia" with 2 to several rhizoids 2
1. "Sporangia" usually with a single rhizoid ..... 4. **G. caudata** (p. 304)
2. "Sporangia" longer than broad (Codiolum-type) .... 1. **G. polyrhiza** (p. 302)
2. "Sporangia" broader than long (Acarid-type) 3
3. Rhizoids nearly simple, stout, blunt ..... 2. **G. Bornetii** (p. 302)
3. Rhizoids branched, slender, acute ..... 3. **G. habrorhiza** (p. 304)

1. **Gomontia polyrhiza** (Lagerh.) B. and F.

Plate 19, fig. 1

"Sporangia" irregularly and broadly clavate to nearly cylindrical, up to 150μ diam., and 240μ long, producing usually several blunt, at times slightly branched rhizoids at the smaller (proximal) end.

Growing in clam shells. Neah Bay, Washington.

Bornet and Flahault, Note sur deux nouveaux genres d'algues perforantes, 1888, pp. 161–163, Sur quelq. pl. viv. dans le test. calc., 1889, pp. cliii-clx, pl. 6–8 (as to combination only); Setchell and Gardner, Phyc. Cont. I, 1920, p. 298, pl. 24, fig. 1. *Codiolum polyrhizum* Lagerheim, Cod. poly. n. sp. etc., 1885 (at least in greater part).

The above description is taken in part from the original of Lagerheim and in part from the material collected at Neah Bay. The material from which Lagerheim drew his description was apparently in the sporangial stage exclusively, as least he did not recognize a sterile, or vegetative stage. The Neah Bay material, collected in May, is likewise in a reproductive stage, or if the vegetative stage is present, it and the sporangial stage could not be identified as belonging to the same species, hence the incompleteness of the description.

The "sporangia" approximate so closely to the figures (especially figs. 10, 11) and the description of Lagerheim as to make it sufficiently safe to ally our plant with his and to keep it distinct from the *G. polyrhiza* of Bornet and Flahault (*G. Bornetii* S. and G.).

The filaments of this species have been examined by us in a specimen distributed by Reinbold from Kiel. Reinbold's specimens have "sporangia" largely of the *Codiolum*-type, both old and young, but it also has an occasional "sporangium" of the Acrid-type (apparently good *G. Bornetii*). Since Reinbold's locality is not far distant from Lagerheim's type locality, it seems extremely probable that his plant is true *G. polyrhiza*. The filaments in Reinbold's specimens are so close to those of *G. Bornetii* as figured by Bornet and Flahault (*loc. cit.*) as to be indistinguishable.

2. **Gomontia Bornetii** S. and G.

Horizontal filaments irregular, much branched, erect filaments with clavate ends, less branched; cells 4–12μ, most frequently 6μ diam., 15–55μ long, cylindrical to more or less swollen and crooked; "sporangia" variable and irregular in form, 80–125μ wide, 150–200μ long,

having numerous blunt, mostly simple rhizoids arising principally on one side, but occasionally promiscuously scattered all over the sporangia; zoospores of two sorts, one 3.5μ wide and 5μ long, the other 5–6μ wide and 10–12μ long, development unknown; aplanospores 4μ diam.

Growing in clam shells. Neah Bay, Washington.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 298.

Gomontia polyrhiza Bornet and Flahault, Notes sur deux nouveaux genres d'algues perforantes, 1888, pp. 161–163 (pp. 3–5, repr.), Sur quelq. pl. viv. dans le test. calc., 1889, pp. clii-clx, pl. 6–8 (not *Codiolum polyrhiza* Lagerheim).

Bornet and Flahault (1889) distinctly state (p. clv) that the greatest dimensions of the "sporangia" in their specimens are 120μ for the height and 75μ for the width and mention that Lagerheim found "sporangia" in his specimens up to 240μ in height and 60μ in breadth. We judge, therefore, that the *Codiolum*-type of "sporangium" which Lagerheim figures (1885, pl. 28, figs. 10, 11 in particular) and describes ("*plerumque plus minus elongatis,*" *loc. cit.* p. 22) was not to be found in the French material and certainly is not illustrated by Bornet and Flahault, unless figure 9 on plate 7 may represent it. The type of "sporangium" illustrated by Bornet and Flahault (1889, pl. 7, 8) belongs to the shorter and broader type, the Acarid-type as it may be called, and has blunt, simple or slightly branched rhizoids. Lagerheim (*loc. cit.*, pl. 28, figs. 7, 8, 12, 13) has also figured "sporangia" of the true Acarid-type and probably found a mixture of species in the shells he examined. Since, however, he emphasizes the elongated, or *Codiolum*-type of "sporangia," it seems best to reserve his specific name for the species with the *Codiolum*-type of "sporangium" and assign the new specific name (*Bornetii* S. and G.) to the species having the Acarid-type of "sporangium" and with blunt, rather stout, simple or, at most, slightly branched rhizoids.

The filaments of *G. Bornetii* are well represented by Bornet and Flahault (1889, pl. 6, figs. 1–8) and by their usually large number of short blunt or almost bulbously enlarged branchlets and their compact massing, make a characteristic appearance after decalcification. They are very similar to those of *G. polyrhiza* so far as we may determine, but somewhat different from those of *G. habrorhiza,* although this difference is not readily described.

While we find what seems referable to *G. Bornetii* in the Puget Sound region and that of central California, we desire more abundant and more decisive material to make us certain.

3. **Gomontia habrorhiza** S. and G.

Plate 19, figs. 2, 3

Filaments repeatedly and irregularly branched; cells very variable in form and size, typically cylindrical, 4–7μ diam., 2–8 times as long; chromatophore without pyrenoids, filling the cell; "sporangia" narrow to wide, bluntly conical, 50–70μ high, 25–60μ wide, developing many very slender, attenuate, dendritically branched rhizoids from the lower side; reproduction unknown.

Growing in dead clam shells. Neah Bay, Washington.

Setchell and Gardner, Phyc. Cont. I, 1920, p. 299, pl. 24, figs. 2, 3.

In certain shells from Neah Bay we have found all the "sporangia" of the Acarid-type and with the processes or rhizoids slender, branched, and attenuated to a point. The "sporangia" seem so distinct from those of *G. Bornetii* that we described the plant possessing them as new. In some shells, we have found the "sporangia" of this species intermingled with others. The vegetative filaments of *G. habrorhiza* seem less entangled and slightly larger than those of either *G. polyrhiza* or *G. Bornetii.*

4. **Gomontia caudata** S. and G.

Plate 18, figs. 1, 2

Filaments short, sparsely branched; cells 5.5–6.5μ diam., 2–12 times as long; chromatophore covering the terminal cells and young "sporangia," broken in the older cells; pyrenoids inconspicuous; "sporangia" clavate, 50–70μ diam., 160–200μ long, tapering to a single rhizoid below with thick, hyaline, homogeneous wall at maturity; rhizoid often becoming much thickened and striated.

Growing in shells of *Mytilus californicus.* Neah Bay, Washington.

Setchell and Gardner, Phyc. Cont., 1920, p. 300, pl. 23, figs. 1, 2.

We have found in shells of the larger edible mussel of our coast a *Gomontia* with filaments seemingly less abundantly branched and "sporangia" (aplanosporangia?) with very thick walls and with a single long rhizoid (cf. pl. 18, figs. 1, 2). These "sporangia" bear a certain resemblance to the "cells" figured by Lagerheim (1885, pl. 28, fig. 4, 6) but are, at least, thicker walled. The fact which seemed to indicate distinctness was that only this type of "sporangium" was found in the shells examined.

FAMILY 13. TRENTEPOHLIACEAE DE-TONI

Thalli filamentous, branched, forming diffuse or feltlike tufts or expansions, in some genera compact and discoidal; cells with one to several nuclei; chromatophore single and band-shaped or several and lenticular, the chlorophyll masked by haematochrome; zoosporangia borne on geniculate or hooked cells, usually deciduous and producing 2-ciliated zoospores; gametangia terminal or intercalary producing 2-ciliated gametes.

De-Toni, Consp. gen. Chloroph., 1888, p. 449; Hansgirg, Ueber Gatt. *Herposteiron,* etc., 1888, p. 222; Collins, Green Alg. N. A., 1909, p. 315; West, Algae I, 1916, p. 305. *Chroolepidaceae* Borzi, Stud. Alg., fasc. 1, 1883, p. 25 (in part).

More recent authors agree in separating Trentepohliaceae from Chaetophoraceae, principally on account of habitat and the presence of haematochrome in the cells, masking the green of the chlorophyll and giving an orange-red or yellow color to the members of this family. The plants belonging to Trentepohliaceae are usually epiphytic, or partially endophytic, but some species of *Trentepohlia* grow upon rocks. Only one member of the family affects, at times, a habitat subject to the direct action of the sea water. Since that member has been found in a marine situation on our coast, we feel compelled to include an account of it.

34. **Trentepohlia** Mart.

Frond composed of dichotomously or irregularly branched, erect filaments of a single series of cells, arising from irregularly branched creeping filaments; branches arising either from the middle or from the upper ends of the cells; color greenish at times in active vegetative condition, changing to yellowish or red, fading to white when dried and dead; cells cylindrical to spherical with thick hyaline walls; chromatophore without pyrenoid, band-shaped or broken; reproduction by 2-ciliated zoospores in sporangia borne on special hooked or curved cells, and by 2-ciliated gametes in lateral, terminal or intercalary transformed vegetative cells.

Martius, Flora Cryptog. Erlang., 1817, p. 351.

The members of this genus are usually found upon wood or the trunks of trees, although certain species are found upon rocks. The rock-inhabiting species as well as those found upon trees, are of

frequent occurrence in the maritime region, especially where fogs are frequent. Only one species, however, is said to be found where actually immersed at high tide and that grows upon wood. The aerial species on rocks and wood are often conspicuous, forming broad patches of yellow or deep orange-red upon the rocks or tree trunks. Those visiting the shore in search of marine algae are very likely to encounter some of these species.

Trentepohlia odorata var. **umbrina** (Kuetz.) Hariot

Filaments forming a more or less dense, at times pulverulent or tomentose stratum, without marked distinction between prostrate and erect positions, flexuous, somewhat torulose, with short branches; color green, varying to brownish or orange-red; cells varying from cylindrical to ovoid, 10–30μ diam., 1–1.5μ times as long; cell wall thin when young, becoming thick and lamellate with age; gametangia spherical to ellipsoid, lateral, terminal or intercalary, 20–30μ diam.; sporangia similar to gametangia.

Growing on piles of Douglas Fir (*Pseudotsuga taxifolia*) along high-tide level. Breakwater, San Pedro Harbor, Los Angeles County, California.

Hariot, Notes sur le genre *Trentepohlia,* 1889, pp. 400–403; Collins, Green Alg. N. A., 1909, p. 319. Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 2288. *Chroolepus umbrinum* Kuetzing, Phyc. Gen., 1843, p. 283, pl. 7, f. 2. *Trentepohlia umbrina* var. *quercina* Collins, Holden and Setchell, Phyc. Bor.-Amer. (Exsicc.), no. 662.

One of us (Gardner) has found what certainly seems to be this species growing on piles of Douglas Fir (*Pseudotsuga taxifolia*) along high-tide level and above, but where frequently immersed in or splashed by the sea water. The zone affected by the tide was of green color, but above, where contact with salt water was less frequent, the color was deep orange. The locality was observed on two occasions several years apart, and the *Trentepohlia* found persisting. The filaments are to be found mostly within the empty wood cells of the piles.

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["Literatur Bericht zur Linnaea, für das Jahr 1830," p. 86, has a notice of the work: "Livraisons 1–3, nos. 1–30, Leipsic 1828 u. 29." This seems to us to imply that part 1 was issued in 1828, covering plates 1–10, part 3 in 1829 covering plates 21–30, while part 2, plates 11–20 may be either 1828 or 1829. Collins in a letter of June 16, 1919, where he writes us the above information, says also, "safe to assume that part 4 was issued in 1835," i.e., plates 31–40.]

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[The title page as above is dated 1809, then follow two pages of the "Preface to the First Fasciculus," dated June 1, 1802, which is also a sort of advertisement. There are 87 consecutively numbered pages of "Introduction," discussions of the systems of Roth, Vaucher, De Candolle and Hudson, and a "Synopsis of the British Confervae." The five pages of Index of this portion are unnumbered. These 87 pages, index and title page were issued probably late in 1809. There are 109 plates consecutively numbered, and mostly dated as to issue, together with one or more pages of text for each species figured. The plates and leaflets of text were undoubtedly issued in fascicles, some of which were numbered, and at various dates. Finally there are five "supplementary plates," done in a very different style from the others and labelled from A–G. They are not dated neither are they accompanied by leaflets of text as are the other 109 plates. From the dates on the plates and the fascicle numbers at the bottom of some of the descriptive leaflets, the work was probably issued as follows:

1802, June 1, "Preface to the First Fasciculus."
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1802, Nov. 1, Fasciculus 2, text and plates 13–20.
1803, June 1, Fasciculus 3, text and plates 21–32.
1803, Nov. 1, Fasciculus 4, text and plates 33–38.
1804, Dec. 1, Fasciculus 5, text and plates 39–44.
1805, Sept. 1, Fasciculus 6, text and plates 45–50.
1805, Dec. 1, Fasciculus 7, text and plates 51–56.
1806, Mar. 1, Fasciculus 8, text and plates 57–62.
1806, June 1, Fasciculus 9, text and plates 63–68.
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1806, Dec. 1, Fasciculus 11, text and plates 76–81.
1807, Mar. 1, Fasciculus 12, text and plates 82–87.
1807, June 1, Fasciculus 13, text and plates 88–93.
1808, July 1, Fasciculus 14, text and plates 94–99.
1809, (Feb. 20?), Fasciculus 15, text and plates 100–105.
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1846, plates 1–72.
1847, plates 73–144.
1848, plates 145–216.
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1853, vol. 3.	1858, vol. 8.	1863, vol. 13.	1868, vol. 18.
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[Judging from Pritzel (Thesaurus, 1851, p. 145) vol. 1 was published in several parts, and probably at different dates. In quoting in the text we have used the date 1845, the first date given in the volume, without discriminating as to the exact date of the publication of the species referred to.]

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[We have been puzzled by the variety of quotation, both as to title and date, given by different writers for this very important work of Ruprecht. Our own copy seems to be the regular issue of "Dr. A. Th. Middendorff's Sibirische Reise" designated as "Band I, Theil 2, Botanik, Zweite Lieferung," etc., whose title page states place of publication as "Buchdruckerei der Kaiserlichen Akademie der Wissenschaften. St. Petersburg, 1851." It is stated that it is to be obtained from "Eggers et Co." of St. Petersburg and from "Leopold Voss" of Leipzig. On the reverse of the front cover is printed the following: "Auf Verfügung der Kaiserlichen Akademie der Wissenschaften. Fuss, beständiger Secretär. December, 1850." The title is the German title given above, viz., "Tange des Ochotskischen Meeres," etc. Pritzel (2nd ed.) gives the date as 1850 and the title as follows: "Algae Ochotenses. Die ersten sichern Nachrichten über die Tange des Octoskischen Meeres." In the account of Ruprecht's life and works in the Bulletin of the St. Petersburg Academy of Sciences for 1871 (Suppl.) the date is given as 1850. Heinsius gives title and date as recorded by Pritzel. The Botanische Zeitung (vol. 9, 1851, p. 443) gives the date as 1850, but later (vol. 14, 1856, p. 553) states that it was issued in 1851. The copy of Middendorff's Reise in the Gray Herbarium has been examined by F. S. Collins, who writes that the Ruprecht portion of "Band I" is distinctly stated to have been "Gedruckt 1856" and he has given this date in his "Green Algae of North America." Kjellman in "The Algae of the Arctic Sea" (1883, p. 331) has given the date as 1848. Under the circumstances, we have retained the date 1851 as best substantiated.]

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[This is a reprint of the above paper, 1901, with change in title, volume, pages and plates. Otherwise it is the same.]

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[From the printed evidence, it is difficult to determine the exact dates of the publication of this large work of Zanardini. The title pages of the volumes bear dates as follows: vol. 1, 1860; vol. 2, 1865; and vol. 3, 1871. These dates are not sufficiently exact for reference as to priority of publication. The three volumes of the Iconographia are made up of reprints from the various parts published in the "Memorie dell' I. R. Istituto Veneto," where they appeared under the title "Scelta di Ficee nuove o piu rare del Mare Adriatico." The general distribution of pages, plates and approximate dates have been collated by Dr. W. G. Farlow and confirmed, so far as possible, by us. They are as follows:

Volume 9 of "Memorie," dated 1860, has part 1, plates 1–8, pages 41–78, was presented April 16, 1860, and is the same as volume 1 of the "Iconographia," plates 1–8, Preface and pages i-iv and 1–34.

Vol. 10, 1861, parts 1?, 2?, pls. 9–16, pp. 93–124, presented June 17, 1861, is vol. 1, pls. 9–16, pp. 35–66.

Vol. 10, 1861, part 3, pls. 26–33, pp. 449–484, presented Apr. 23, 1862, is vol. 1, pls. 17–24, pp. 67–102.

Vol. 11, 1862, part 2, pls. 11–18, pp. 271–306, presented Apr. 15, 1863, is vol. 1, pls. 25–32, pp. 103–138.

Vol. 12, 1864, part 1, pls. 1–8, pp. 9–43, presented May 30, 1864, is vol. 1, pls. 33–40, pp. 139–175.

Vol. 12, 1864, part 2, pls. 14–21, pp. 377–410, presented May 22, 1865, is vol. 2, pls. 41–48, preface, index and pp. iii-viii, 1–32.

Vol. 13, 1866, part 1, pls. 2–9, pp. 143–176, no date of presentation, is vol. 2, pls. 49–56, pp. 33–66.
Vol. 13, 1866, parts 2?, 3?, pls. 10–17, pp. 403–434, presented May 27, 1867, is vol. 2, pls. 57–64, pp. 67–98.
Vol. 14, 1869, part 2, pls. 4–11, pp. 181–216, presented June 22, 1868, is vol. 2, pls. 65–72, pp. 99–134.
Vol. 14, 1870, part 3, pls. 26–33, pp. 437–472, presented June 21, 1869, is vol. 2, pls. 73–80, pp. 135–168.
Vol. 15, 1871, part 2, pls. 10–17, pp. 425–460, presented June 20, 1870, is vol. 3, pls. 81–88, pp. 5–36.
Vol. 17, 1873, part 3, pls. 14–21, pp. 429–460, presented Dec. 22, 1872, is vol. 3, pls. 89–96, pp. 37–68.
Vol. 18, 1874, part 1, pls. 2–9, pp. 255–286, presented Dec. 22, 1873, is vol. 3, pls. 97–104, pp. 69–100.
Vol. 19, 1876, part 3, pls. 23–30, pp. 513–544, presented June 18, 1876, is vol. 3, pls. 105–112, pp. 101–132.]

EXPLANATION OF PLATES

PLATE 9

Hormiscia sphaerulifera S. and G.

Fig. 2. A, basal portion of filament showing intramatrical rhizoids. B, vegetative cells in the median portion of the filament. C, an empty sporangium. × 25.

Hormiscia grandis (Kylin) S. and G.

Fig. 3. A, basal portion of filament showing numerous intramatrical rhizoids. B, two zoosporangia of moderate size. C, a long typical zoosporangium, empty. D, moderate sized vegetative segments. × 80.

Hormiscia penicilliformis (Roth) Fries

Fig. 4. A, sporeling with rhizoid penetrating a filament of *Ulothrix flacca*. B, basal portion of a young filament, showing a few intramatrical rhizoids. C, characteristic zoosporangia. D, young vegetative segments. × 80.

Rhizoclonium lubricum S. and G.

Fig. 5. A, terminal portion of a young filament with short segments. B, terminal portion of a filament with long, "resting segments." × 160.

Ulothrix pseudoflacca f. *maxima* S. and G.

Fig. 6. A, B, vegetative filaments. C, sporangia. × 250.

Codium dimorphum Svedelius

Fig. 7. A young utricle with an empty sporangium. × 80.

Fig. 8. A terminal portion of a utricle, showing the extremely thick, lamellate and tuberculate end wall. × 100.

Codium intertextum var. *crilosum* M. A. Howe

Fig. 9. Portion of the end wall of a utricle, showing internal modifications. × 100.

Codium Setchellii Gardner

Fig. 10. Typical utricle and sporangium, showing the scars of three previous sporangia. × 80.

Fig. 11. Showing different forms of utricles and sporangia.

This plate is from Gardner, New Pac. Coast Mar. Alg. IV, 1919, pp. 487–496, pl. 42. Fig. 9 was labeled *Codium adhaerens*.

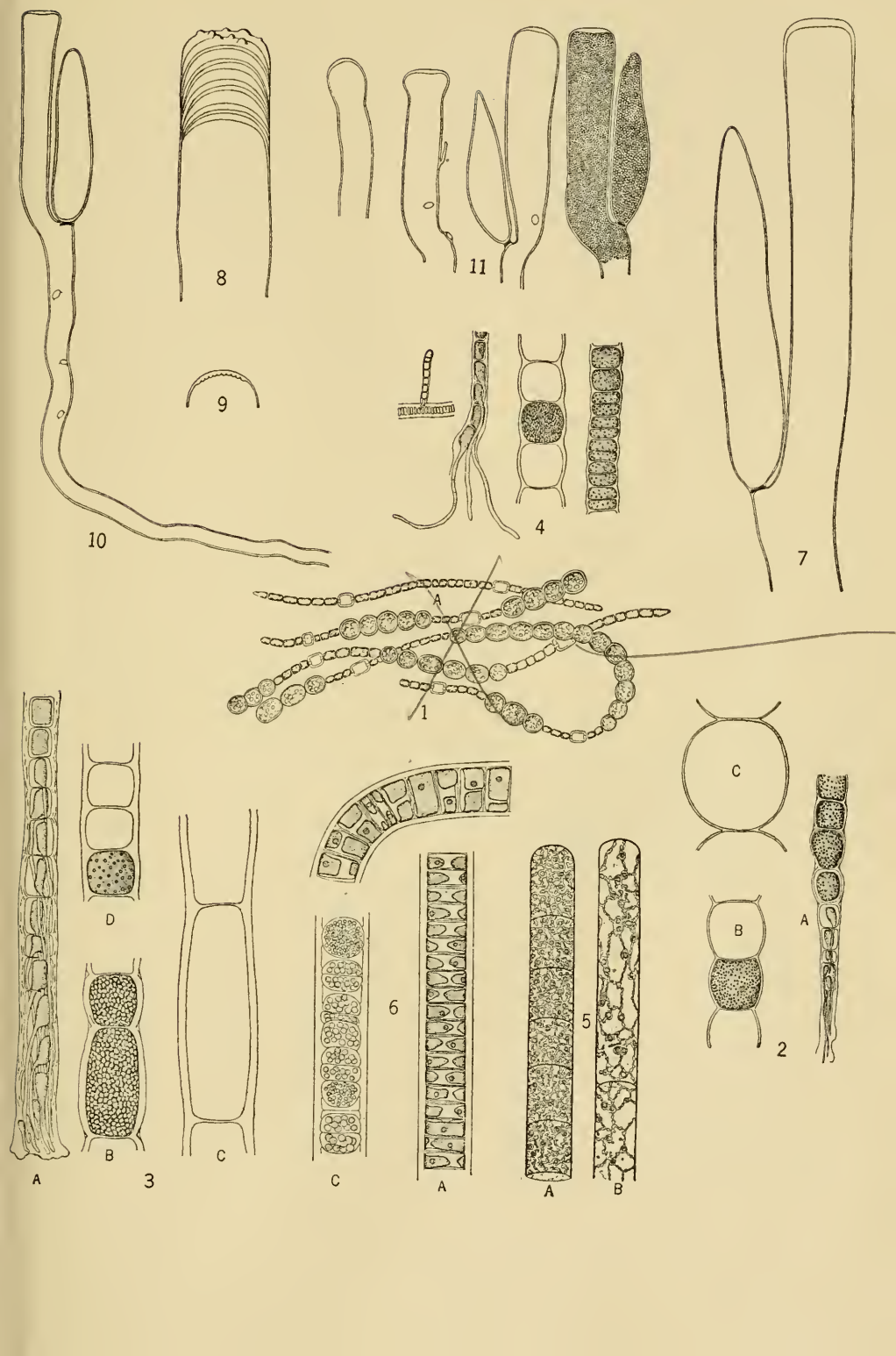
8
11
9
10
4
7
A
1
C
B
A
2
D
B
A
3
C
6
C
A
A
5
B

PLATE 10

Prasiola borealis Reed

Fig. 1. A group of whole plants infested by the parasitic fungus, *Guignardia alaskana* Reed. × 3.5.

Fig. 2. A cross section of the frond. × 375.

Fig. 3. A surface view at the margin of the frond showing the grouping of the cells. × 285.

Figures 1–3 are from Reed, Two new Asco. Fungi, 1902, pp. 141–164, pls. 15, 16.

Collinsiella tuberculata S. and G.

Fig. 4. Habit sketch of a group of plants. × 4.

Fig. 5. A vertical section through one of the fronds.

Fig. 6. Dissection of a part of the vertical section which has been treated with Chloriodide of Zinc to show the branching. The cell contents are much shrunken.

Fig. 7. A tangential section at the surface to show the division planes.

Fig. 8. A terminal cell showing a diminished chromatophore and two pyrenoids.

Fig. 9. A terminal cell showing the vacuolated appearance of the chromatophore.

Fig. 10. A young terminal cell showing a complete parietal chromatophore and one pyrenoid.

Figures 4–10 are from Setchell and Garder, Alg. N.W. Amer., 1903, pp. 165–418, pl. 17.

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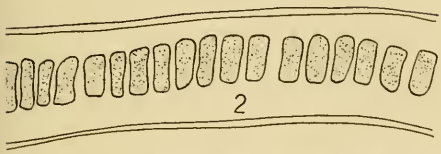
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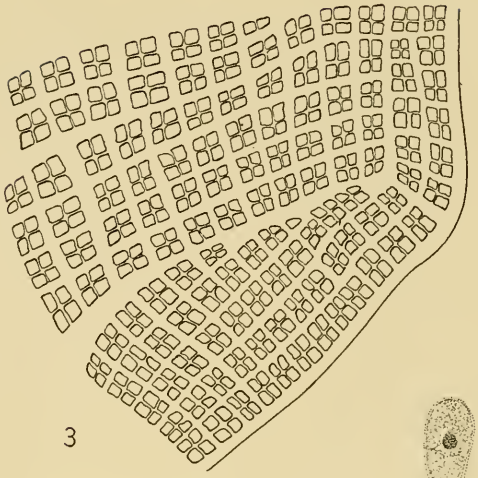
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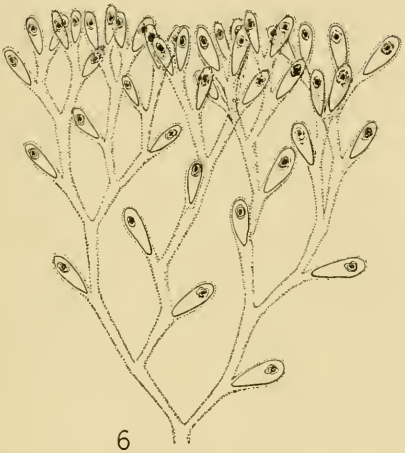
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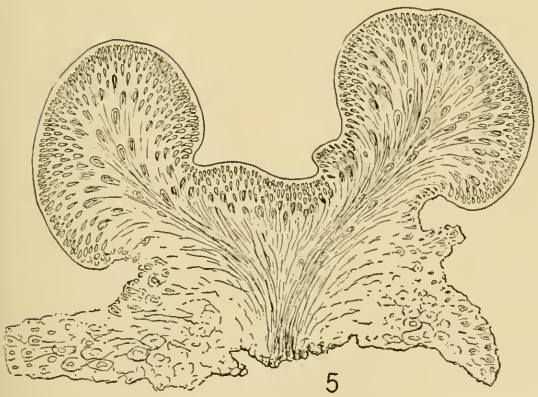
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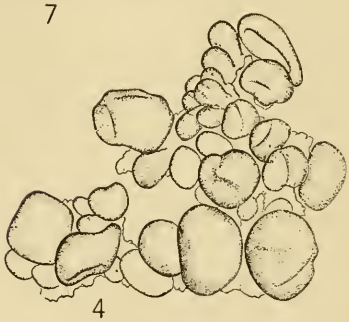
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PLATE 11

Pseudulvella prostrata (Gardner) S. and G.

Fig. 1. Showing a small section of the margin of the thallus on the surface of *Iridaea laminarioides*.

Fig. 2. A vertical section of fig. 1, perpendicular to the long diameter of the filaments of *Ulvella:* the drawing is imperfect, it should show a common enclosing cuticle.

Endophyton ramosum Gardner

Fig. 3. Showing the narrow filaments within the central part of the host, *Iridaea laminarioides*, terminating in sporangia at the surface.

Fig. 4. Showing pieces of irregularly shaped filaments.

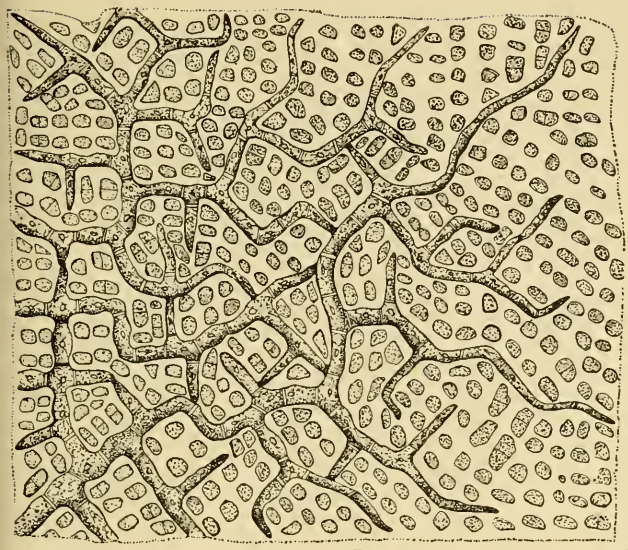
Pseudodictyon geniculatum Gardner

Fig. 5. A part of a thallus showing a few terminal filaments penetrating among the cortical cells of *Laminaria Sinclairii*.

Fig. 6. A cross section of fig. 5, showing terminal sporangia on short, erect filaments.

All highly magnified.

This plate is from Gardner, New Chlorophyceae from California, 1909, pp. 371–376, pl. 14.



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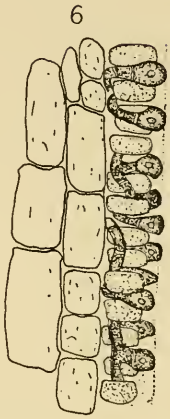

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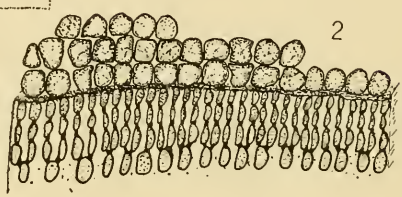

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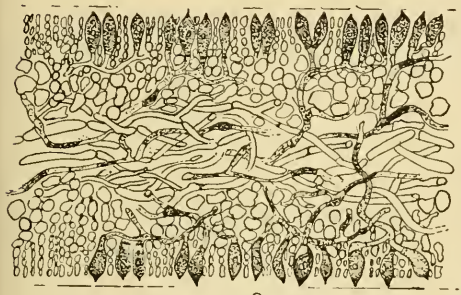

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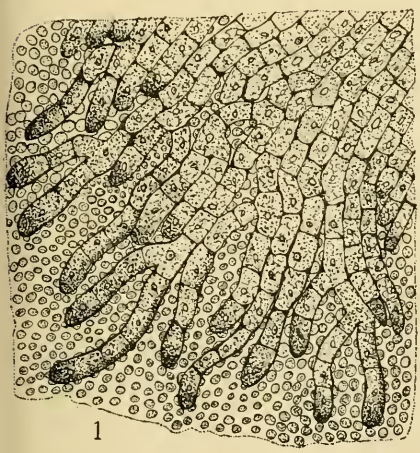

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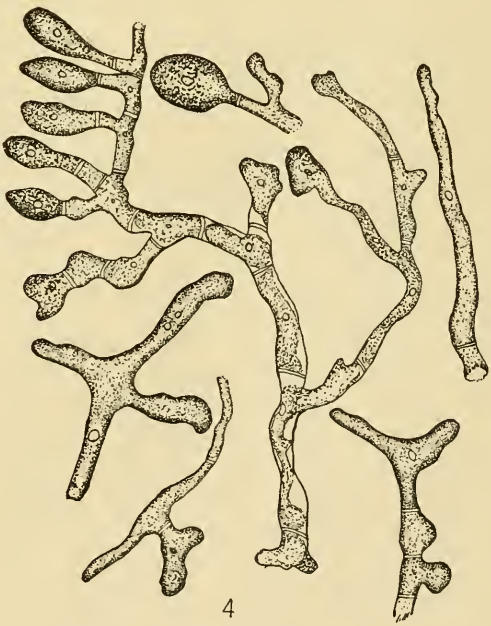

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PLATE 12

Ulva Linza L.

Fig. 1. A vertical section through the margin of a frond showing the separation of the two layers. Plant from Friday Harbor, Washington. × 250.

Fig. 2. A surface view of fig. 1. × 250.

Fig. 3. The same view as fig. 1. Plant from Admiralty Island, Alaska. × 250.

Fig. 4. A surface view of fig. 3.

Gayella constricta S. and G.

Fig. 5. Habit sketch of a whole plant. × 30.

Fig. 6–8. Showing the development of rhizoids.

Fig. 9. Two enlarged segments showing shapes and arrangement of the cells in surface view. × 100.

Fig. 10. A cross section of a large segment showing the radial arrangement of the cells.

Figures 5–10 are from Gardner, New Pac. Coast Mar. Alg. I, 1917, pp. 377–416, pl. 33.

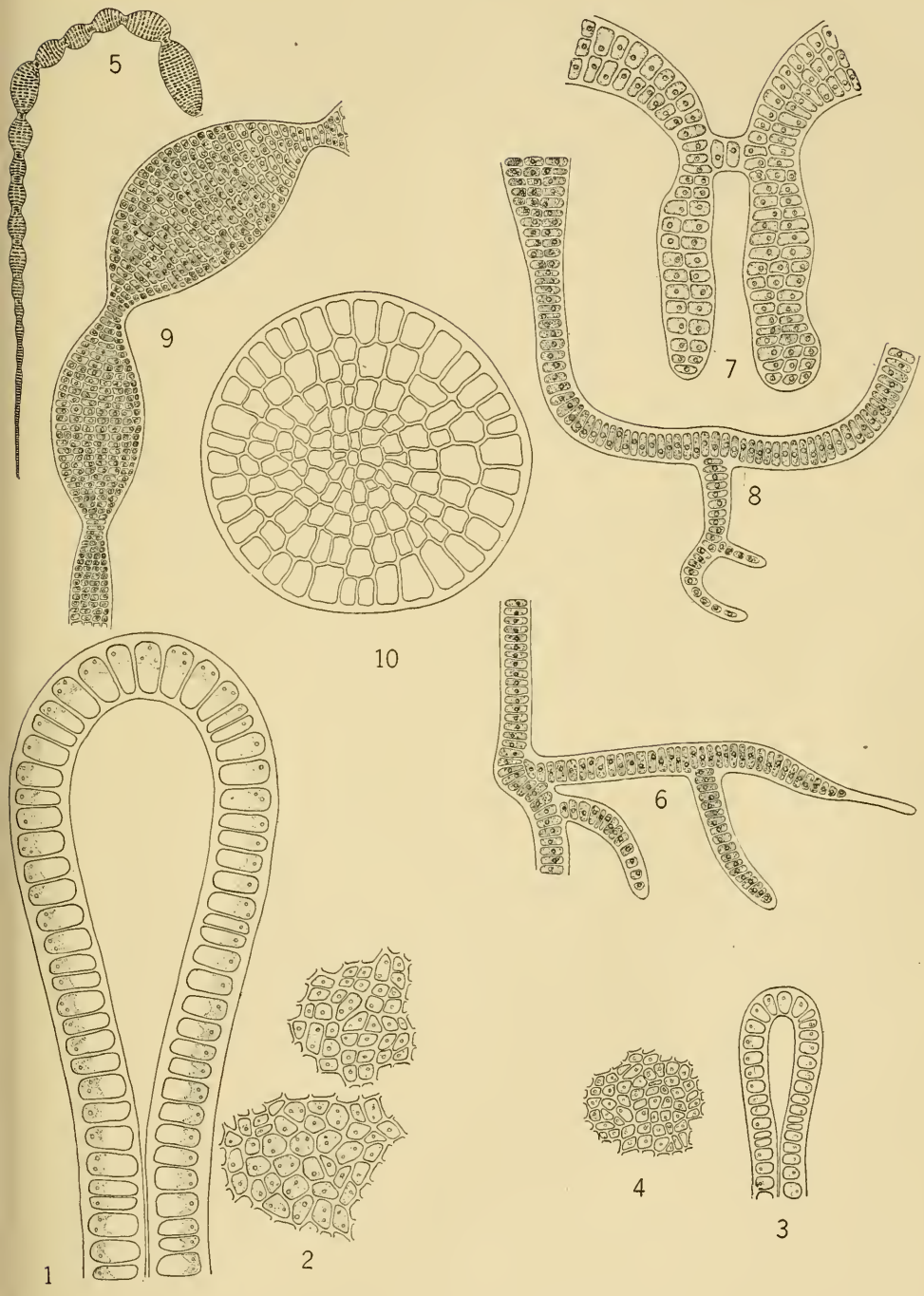
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PLATE 13

Chlorochytrium inclusum Kjellm.

Fig. 1. A vertical section through the host, showing the penetration of the endophyte to the medulla. × 250.

Cladophora microcladioides Collins

Fig. 2. Showing the method of branching of the terminal ramuli. × 8.

Halimeda discoidea Dec'ne

Fig. 3. A habit sketch of a small plant. × 1.

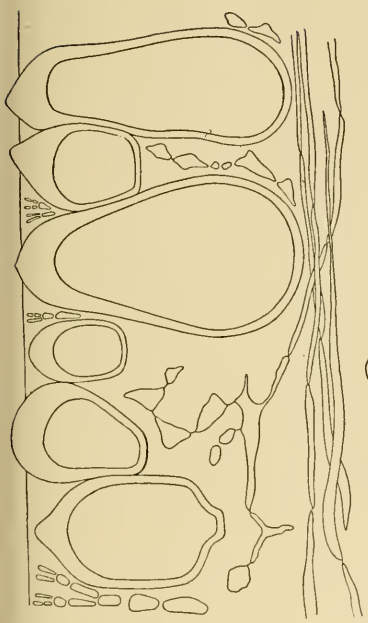

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PLATE 14

Bryopsis plumosa (Huds.) Ag.

Fig. 1. Diagrammatic illustration of a whole plant showing the method of branching. × 1.

Fig. 2. A sketch of a branch showing the arrangement, the relative length and the constriction of the bases of the pinnules. × 40.

Halicystis ovalis (Lyngb.) Aresch.

Fig. 3. A habit sketch of a whole plant except the rhizoidal base. × 2.

Enteromorpha tubulosa Kuetz.

Fig. 4. A portion of a small frond showing the linear arrangement of cells. × 250.

Fig. 5. A section of a frond. × 250.

Percursaria percursa (Ag.) Rosenv.

Fig. 6. A portion of a frond showing one row of cells at one end and two rows at the other. × 250.

Enteromorpha compressa (L.) Grev.

Fig. 7. A vertical section through the frond. × 250.

Fig. 8. A surface view. × 250.

Chaetomorpha aerea (Dillw.) Kuetz.

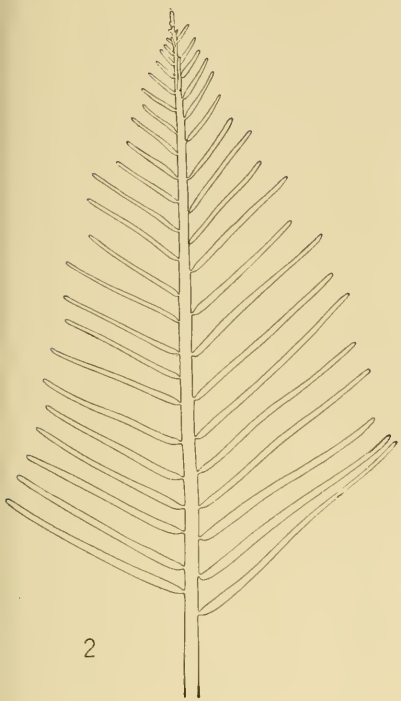
Fig. 9. A group of young plants showing long basal cells with rhizoids. × 35.

Figs. 10, 11. Sketches showing different ages of the cells in vegetative stages. × 35.

Monostroma zostericola Tilden

Fig. 12. A surface view. × 500.

Fig. 13. A vertical section. × 500.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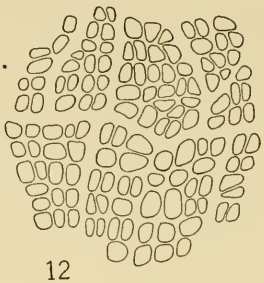
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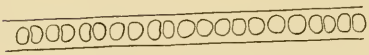
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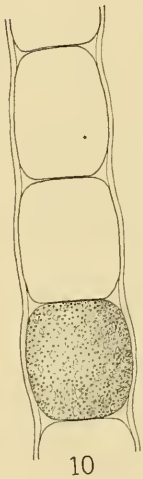
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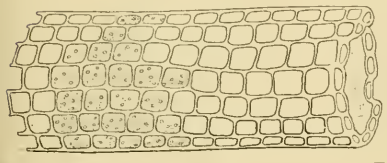
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PLATE 15

Chlorochytrium Porphyrae S. and G.

Fig. 1. A vertical section through the host, showing plants of the endophyte in various stages of development and of embedding. × 140.

Codiolum gregarium A. Br.

Fig. 2. A group of three plants. × 120.

Derbesia marina (Lyng.) Kjellm.

Fig. 3. A part of a filament showing the method of branching, and one sporangium. × 65.

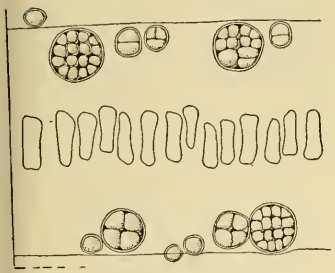
Bryopsis corticulans Setchell

Figs. 4, 5. Sketches showing origin and method of development of the corticating filaments. × 25.

Codium latum Suring.

Fig. 6. Sketch of a single utricle showing the position of the sporangia and of the hairs. × 100.

Figure 1 is from Gardner, New Pac. Coast Mar. Alg. I, 1917, pp. 377–416, pl. 32, fig. 6.



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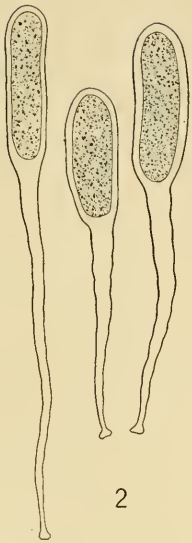

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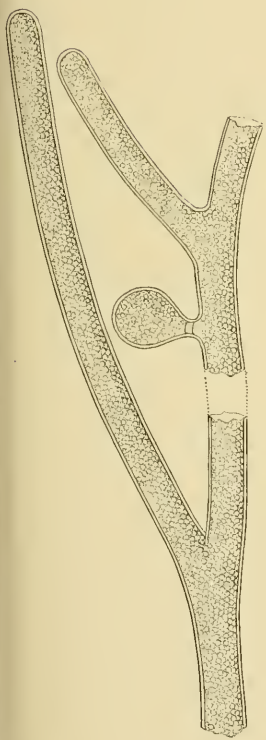

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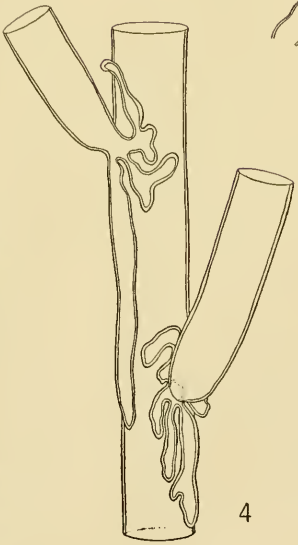

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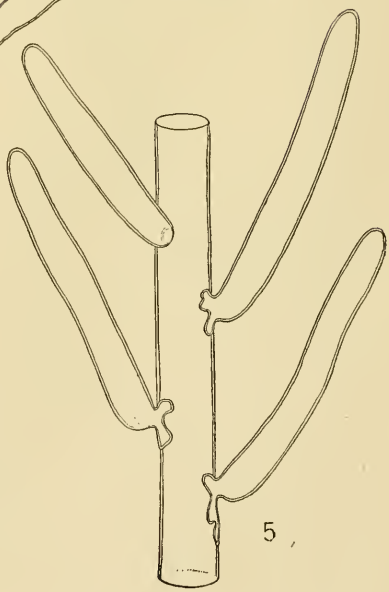

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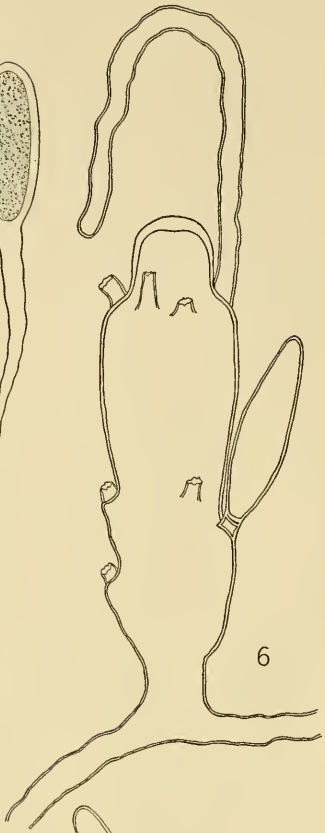

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PLATE 16

Enteromorpha micrococca var. *subsalsa* Kjellm.

Fig. 1. A habit sketch of a piece of a frond showing the method of branching. × 20.

Cladophora trichotoma (Ag.) Kuetz.

Fig. 2. A habit sketch of a few terminal ramuli.

Enteromorpha compressa (L.) Grev.

Fig. 3. A habit sketch of a frond. × 1.

Spongomorpha coalita (Rupr.) Collins

Fig. 4. Sketch showing the characters of the hooked branches. × 10.

Codium Ritteri S. and G.

Fig. 5. A sketch of a group of utricles. × 25.

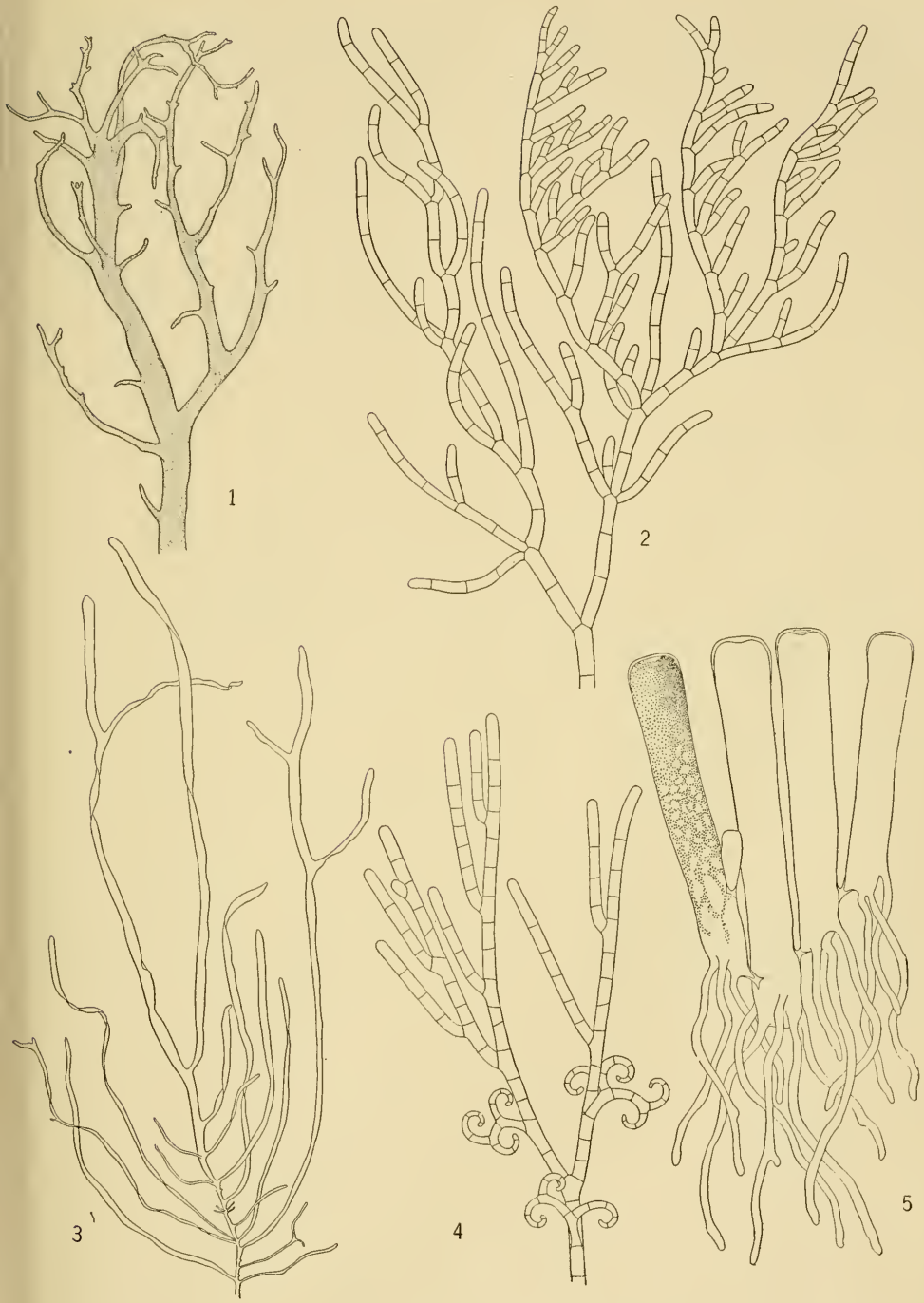
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PLATE 17

Pseudopringsheimia apiculata S. and G.

Fig. 1. A section through the thallus of a mature plant perpendicular to the host. × 250.

Fig. 2. A section through the thallus of a young plant. × 250.

Prasiola delicata S. and G.

Fig. 3. a-f, Series of different forms of plants. × 10.

Ulva vexata S. and G.

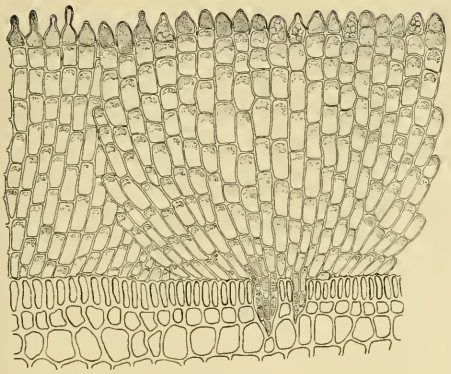
Fig. 4. A group of plants showing different shapes and sizes. × 1.

Fig. 5. A group of mature plants showing the presence of the parasitic fungus, *Guignardia Ulvae* Reed. × 3.

Fig. 6. A cross section showing the presence of fungal hyphae in the medulla. × 250.

Fig. 7. A surface view. × 250.

This plate is from Setchell and Gardner, Phyc. Cont. I, 1920, pp. 279–324, pl. 22.



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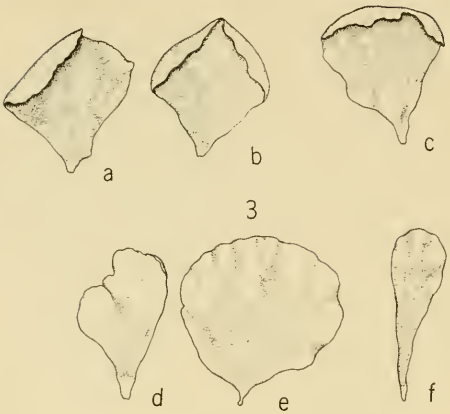

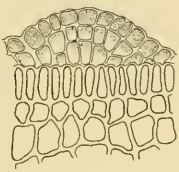

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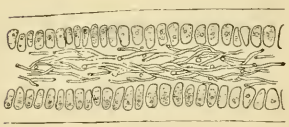

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PLATE 18

Gomontia caudata S. and G.

Fig. 1. Two pieces of filaments. × 400.

Fig. 2. a-d, Different stages and forms of "sporangia." × 400.

Internoretia Fryeana S. and G.

Fig. 3. A surface view of the host plant, showing the method of permeation and branching of a few terminal filaments. × 375.

Fig. 4. A stage slightly in advance of fig. 3, showing cell divisions in planes parallel to the long diameter of the cells. × 375.

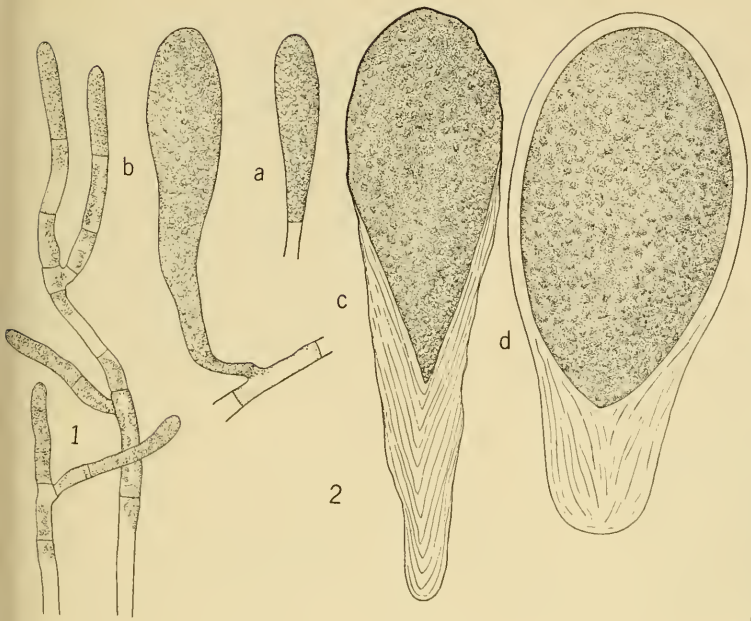
Fig. 5. A stage in development nearing maturity. × 375.

Fig. 6. A cross section of the host cutting the filaments of *Internoretia* at right angles to their long diameter. × 375.

Entocladia cingens S. and G.

Fig. 7. A plant growing in the membrane of *Chaetomorpha californica* and nearing maturity. × 250.

This plate is from Setchell and Gardner, Phyc. Cont. I, 1920, pp. 279–324, pl. 23.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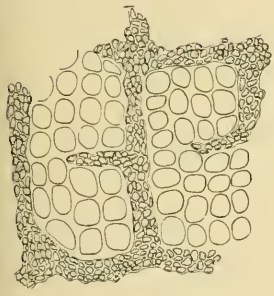
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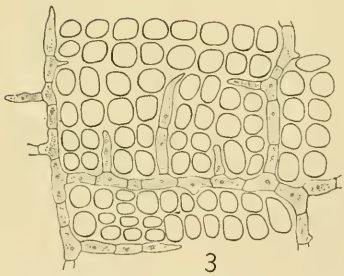
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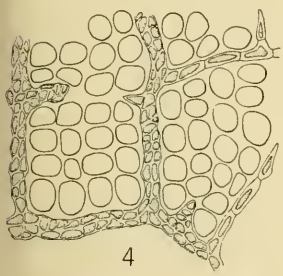
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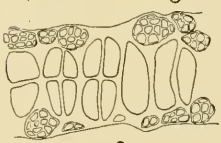
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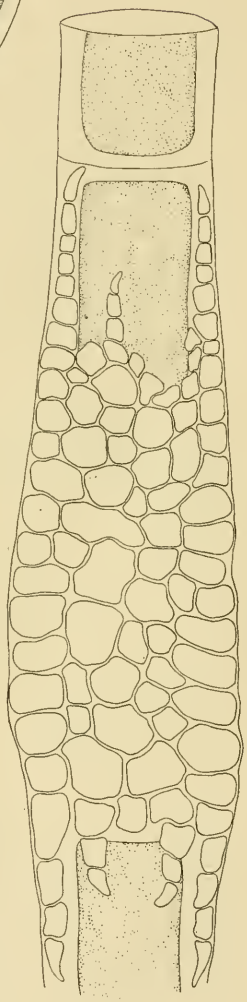
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PLATE 19

Gomontia polyrhiza (Lagerh.) B. and F.

Fig. 1. A group of three "sporangia," the two larger nearing maturity. × 175.

Gomontia labrorhiza S. and G.

Fig. 2. A young thallus. × 375.

Fig. 3. a-e, Illustrating three forms of the "sporangia."

Pseudulvella consociata S. and G.

Fig. 4. A surface view of a young thallus. × 375.

Fig. 5. A section of a mature thallus. × 375.

Fig. 6. A vertical filament near the surface of a young thallus showing branching. × 225.

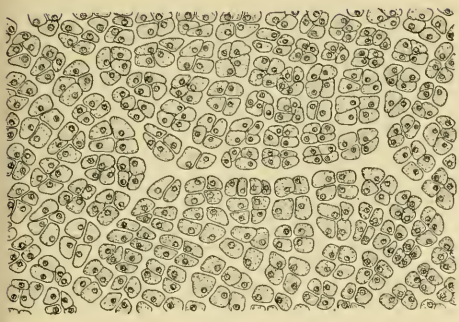
Entocladia codicola S. and G.

Fig. 7. a, A young thallus, showing the method of branching of the filaments and of their radiation from a center. × 125. b, A mature thallus with sporangia in the center. × 125.

Prasiola delicata S. and G.

Fig. 8. A surface view showing typical arrangement of cells. × 500.

This plate is from Setchell and Gardner, Phyc. Cont. I, 1920, pp. 279–324. pl. 24.



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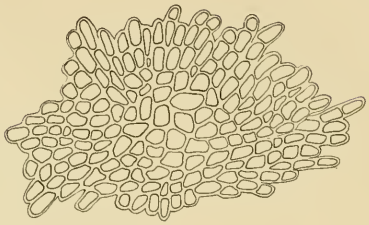

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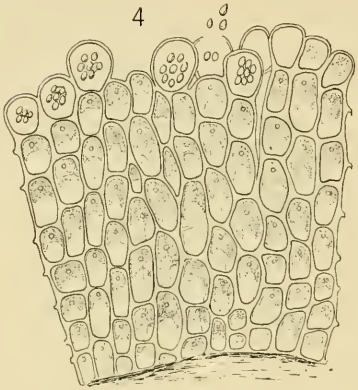

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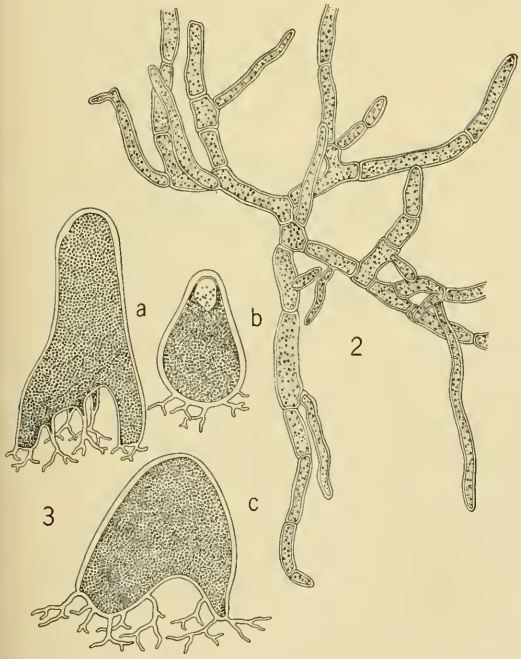
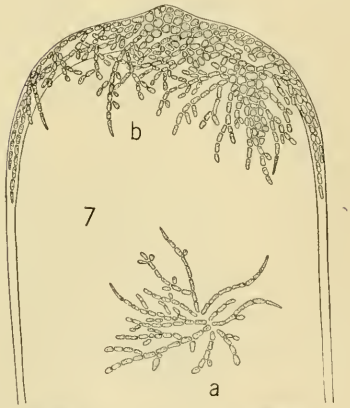




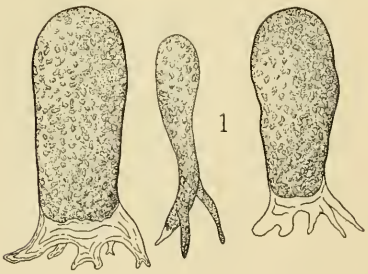


PLATE 20

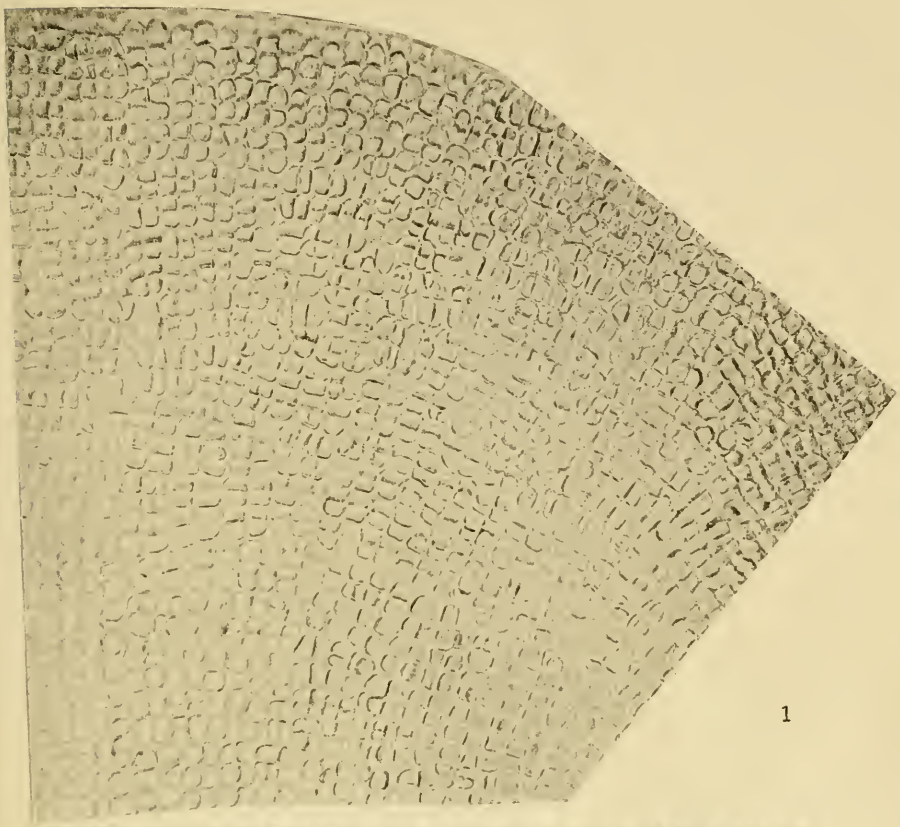
Prasiola delicata S. and G.

Fig. 1. A micro-photograph of a marginal segment, surface view showing the arrangement of the vegetative cells. × 442.

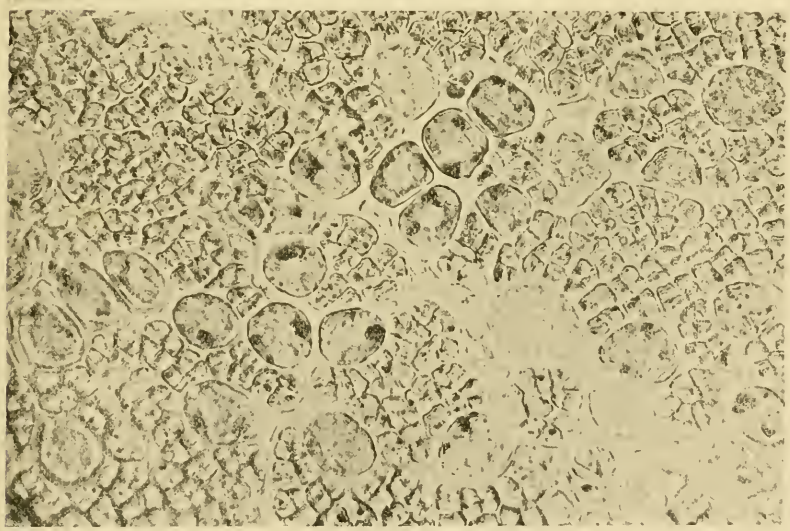
Prasiola meridionalis S. and G.

Fig. 2. A micro-photograph of a portion of the surface, showing vegetative cells and interspersed aplanospores (?). × 442.

This plate is from Setchell and Gardner, Phyc. Cont. I, 1920, pp. 279–324, pl. 25.



1



2

PLATE 21

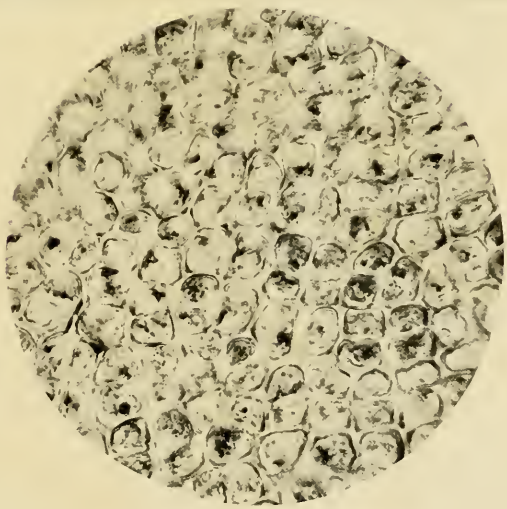
Ulva dactylifera S. and G.

Fig. 1. Photograph of a whole plant, with the exception of a portion of the base, the type. × 0.75.

Ulva stenophylla S. and G.

Fig. 2. A micro-photograph of a portion of the surface, showing the rounded angles and relatively thick walls of the cells. × 442.

1



2

PLATE 22

Ulva angusta S. and G.

A photograph of a group of plants, the type.

PLATE 23

Ulva taeniata (Setchell) S. and G.

A photograph of a whole dried plant, showing the extreme crisped nature of the dentate margins at the base. × 0.3.

PLATE 24

Ulva stenophylla S. and G.

A photograph of a whole plant, the type. × 0.3.

PLATE 25

Monostroma areolatum S. and G.

A photograph of a whole dried plant, the type. × 0.5.

PLATE 26

Ulva angusta S. and G.

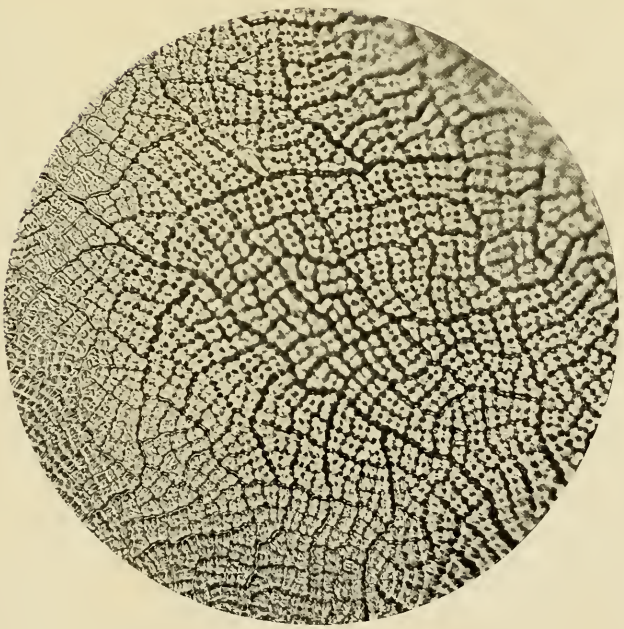
Fig. 1. A micro-photograph of a part of the surface. × 442.

Monostroma areolatum S. and G.

Fig. 2. A micro-photograph of a part of the surface.

Plates 21–26 are from Setchell and Gardner, Phyc. Cont. I, 1920, pp. 279–324, pls. 26–31.

1



2

PLATE 27

Bryopsis corticulans Setchell

A photograph of a whole plant. × 1.

PLATE 28

Codium fragile (Suring.) Hariot

A photograph of an entire dried plant, showing several fronds arising from the same expanded holdfast. × 0.5.

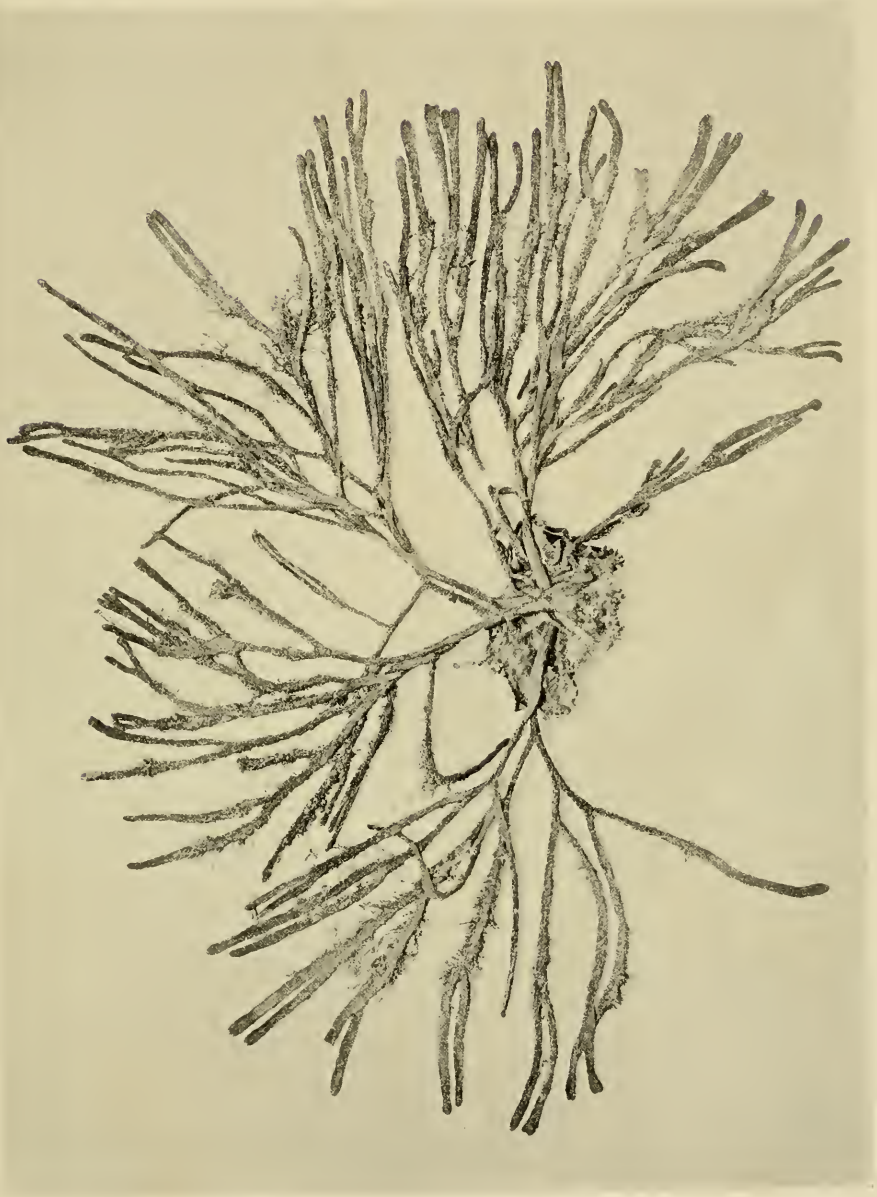


PLATE 29

Codium fragile (Suring.) Hariot

A photograph of a dried frond, showing long, slender branches and dichotomous branching. × 0.5.

PLATE 30

Codium Setchellii Gardner

A photograph of a part of a thallus. × 1.

PLATE 31

Codium sp.

A photograph of a part of a dried plant.

PLATE 32

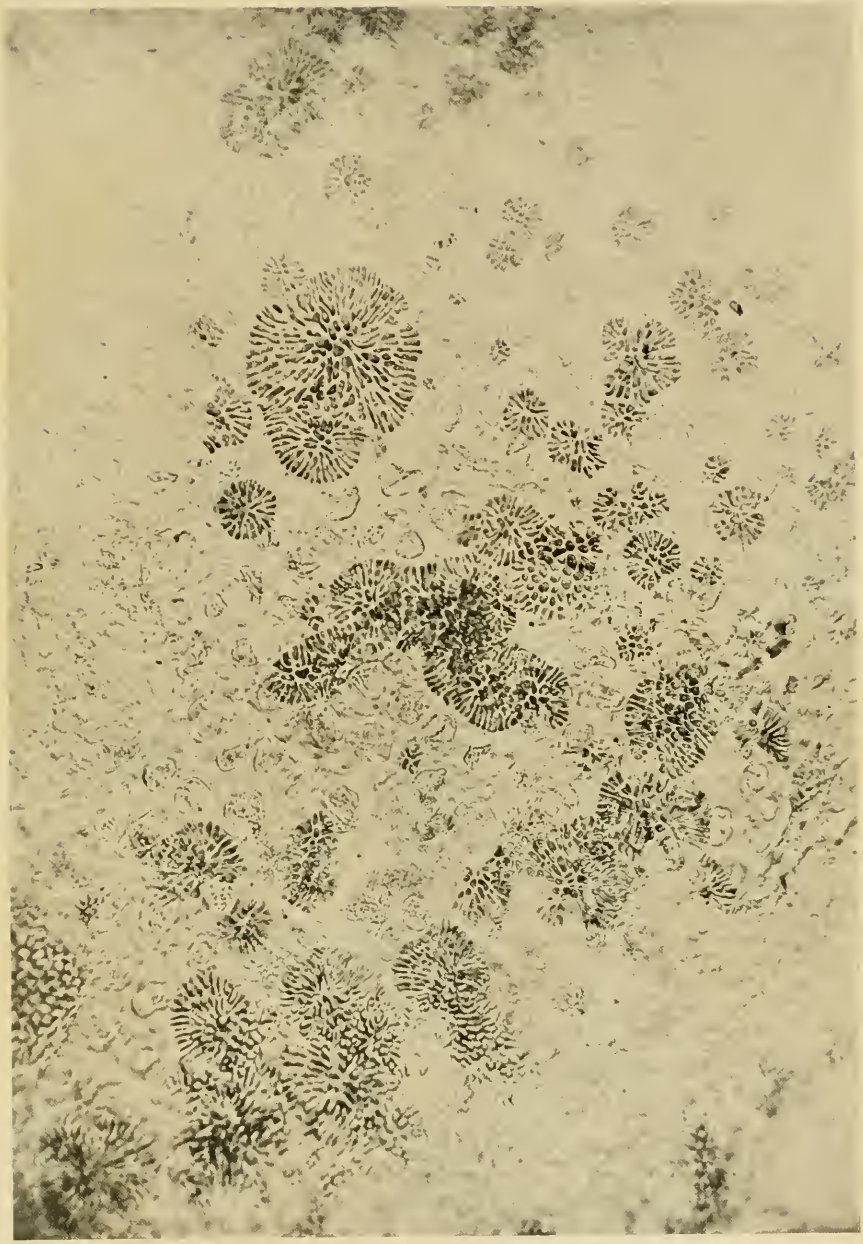
Spongomorpha coalita (Rupr.) Collins

A photograph of a group of plants showing the method of combining into rope-like masses. × 0.5.

PLATE 33

Ulvella Lens Crouan

A micro-photograph showing plants in various stages of development. × 200.



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ERRATA

Page 54, next to last line. *For* algae *read* alga.
Page 85, line 35. *For* Rootb., *read* Rottb.
Page 86, line 6. *For* Sirococoleum *read* Sirocoleum.
Page 109, last line. *For* Forti *read* Kirchner.
Page 114, line 26. *For* Anabaena *read* Anabaina.
Page 115, line 7. *For* two *read* 2.
Page 115, line 38. *For* cognitarium *read* cognitarum.
Page 143, line 1. Delete (MENEGHINI).
Page 143, line 27. Delete (DECAISNE).
Page 153, line 6. Delete (GREV) and add (emend.) after Oltmanns.
Page 156, line 1. Delete (BORY).
Page 156, line 32. *For* Bryopsidaceae *read* Bryopsideae.
Page 163, line 1. Delete (THURET).
Page 163, line 18. Delete 'out.'
Page 166, line 9. Delete (TREVIS).
Page 179, line 1. Delete (BLACKMANN AND TANSLEY).
Page 207, line 18. *For* antidates *read* antedates.
Page 215, line 13. *For* Ovoidea *read* ovoidea.
Page 219, line 4. Delete 1732, ed. 1.
Page 219, next to last line. *For* Ucluet *read* Ucluelet.
Page 227, line 2. *For* cells *read* segments.
Page 256, line 30. At end of line insert (*sub. E. flexuosa*).
Page 260, line 27. *For* filing *read* filling.
Page 264, line 26. Insert comma after diam.
Page 273, line 5. *For* teniata *read* taeniata.
Page 275, line 23. *For* Blatosporaceae *read* Blastosporaceae.
Page 288, line 18. *For* piliferem, *read* piliferum.
Page 289, line 35. *For* Stechell *read* Setchell.
Page 302, line 25. *For* Keil *read* Kiel.
Page 302, line 27. *For* Acrid-type *read* Acarid-type.
Page 307, line 8. *For* 1–268 *read* 1–168.
Page 307, line 9. *For* 269–531 *read* 169–531.
Page 310, line 39. *For* Jajonicae *read* Japonicae.
Page 311, line 36. *For* 1909 *read* 1809.
Page 311, line 38. *For* 1909 *read* 1809.
Page 314, line 30. *For* Ulrothricaceae *read* Ulothricaceae.
Page 315, after line 13. *Insert* 1762. Flora Anglica, ed. 1. London.
Page 319, line 42. *For* Illutrationes *read* Illustrationes.
Page 319, line 42. *For* inprimio *read* inprimis.
Page 320, line 35. *For* marine *read* marines.
Page 326, line 23. *For* cribosum, *read* cribrosum.
Page 370. Add (No. 628, Collins, Holden, and Setchell, Phyc. Bor.-Am., referred under *Codium Lindbergii*; cf. p. 175 of text.)

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